The Australian and New Zealand Journal of Surgery

JANUARY, 1942.

TABLE OF CONTENTS.

[The Whole of the Literary Matter in THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY is Copyright.]

ORIGINAL ARTICLES— PAGE

Report on the Early Treatment and Results of Penetrating Wounds of the Chest ..... *C. W. B. Littlejohn* 147

Surgical Experiences in the Middle East ..... *Julian Smith* 153

Base Hospital Management of Soft Tissue Injuries ..... *B. K. Rank* 171

Preliminary Report on Internal Derangements of the Knee Joint Treated at an Australian General Hospital, Australian Imperial Force Abroad, to May 31, 1941 ..... *R. V. Graham* 185

Ankylosis of the Jaw: Cartilage Graft Restoration of the Joint: A New Operation ..... *H. P. Pickerill* 197

The Use of Kangaroo Tendon for Muscle and Tendon Suture *E. R. Trethewie and E. Williams* 207

EDITORIAL—

War-Time Surgery 209

SURGERY IN OTHER COUNTRIES—

Tomography of the Larynx and Trachea in Relation to Thyreoidectomy ... 212

Chronic Malignant Granulocytopenia Treated with Splenectomy: Recovery 213

Is Urography a Reliable and Valuable Aid in Obtaining a Differential Diagnosis in Acute Appendicitis? 214

Double Gall-Bladder 215

REVIEWS—

Illustrations of Regional Anatomy 216

Editorial Notices.

Editorial communications should be addressed to the Chairman of the Editorial Committee, 57 Collins Street, Melbourne, or to any member of the Editorial Committee. It is understood that original articles forwarded for publication are offered to THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY solely, unless the contrary be stated.

Reprints can be supplied at cost price; the minimum number is fifty copies. Orders for reprints must be given when the proof is returned.

Exchange journals should be addressed to the Honorary Librarian, Royal Australasian College of Surgeons, Spring Street, Melbourne, C.1, Victoria, Australia.

Business communications and remittances should be addressed to Butterworth and Co. (Australia) Ltd., 6-8 O'Connell Street, Sydney.

The announcements appearing in this journal contribute largely towards the maintenance of the high standard of the publication. It is, therefore, requested that, wherever possible, readers will support the business houses whose advertisements appear in the journal and that, when placing their orders, they will mention THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY.

THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

Registered at the General Post Office, Melbourne, for transmission by post as a periodical.

VOL. XI. JANUARY, 1942. No. 3.

REPORT ON THE EARLY TREATMENT AND RESULTS OF PENETRATING WOUNDS OF THE CHEST.[1]

By C. W. B. LITTLEJOHN,
Lieutenant-Colonel, Australian Army Medical Corps, Abroad.

THIS report is based on the details of the first 100 cases of penetrating wounds of the chest treated at an Australian general hospital.

During the months of April, May, June and July of 1941 this hospital, although nominally a general hospital, was functioning—and still continues to function—as a casualty clearing station. Our larger equipment and personnel enable us to retain patients for a considerable period, which may be advisable either in the interests of the patient or because of the difficulties of transport.

The line is ten or twelve miles distant, and the time lag from the line is generally six to eight hours. This may be much increased when a man is wounded in an isolated forward post. Many casualties, on the other hand, as a result of shelling and aerial bombing, occur in the immediate vicinity of the hospital or even in the hospital itself. In these the time lag is minimal. An average is therefore of little value, and as far as possible a note of the time lag is made in each individual case. It is rather surprising how few of the men have any idea of the time at which they were wounded.

Soldiers with chest wounds receive immediate attention in the field, at a regimental aid post, at a dressing station or at the hospital itself. Most of the sucking wounds are now sutured in the more forward areas, but in the earlier months the majority arrived unclosed. Unfortunately a large number of casualties have multiple wounds, which greatly increases their hazard.

The immediate routine treatment is rest, warmth and morphine. After removal of obvious foreign matter, clothing *et cetera,* sucking wounds are sutured, usually without any formal excision of skin edges and devitalized tissue. Silkworm gut sutures are passed deeply and tied firmly. The commonly used mattress suture is liable to strangle a mass of tissue, and should not be used. If necessary, under local anæsthesia a flap is cut and drawn across to close an opening in the thoracic wall. Packing, plugging and adhesive tape do not close the opening satisfactorily; many wounds apparently controlled by such measures will suck immediately the patient changes his position.

Movement of the patient is restricted to an absolute minimum, and many patients have been retained for days in the resuscitation ward. In pursuance of this principle, few of the patients have had X-ray examinations during the early days of their treatment.

[1] Accepted for publication on November 3, 1941.

If other injuries require immediate attention, this is given under "Pentothal", local or block anæsthesia. If much blood has been lost owing to other injuries, or to a leaking hæmothorax, a transfusion may be given. If the chest wound is the only injury, and there has not been any leaking hæmothorax, transfusion is inadvisable.

As soon as possible the patient is propped up in bed in a sitting position, supported by mattresses, pillows and "donkey". Oxygen is given freely through a nasal tube. Our "B.L.B." masks are all out of order owing to immersion in salt water, and few patients will tolerate the Haldane apparatus. All the patients with chest wounds, except those retained in the resuscitation ward, are grouped in ward 1, and as many as fifteen have been under treatment at one time.

CLASSIFICATION OF CASES.

The most satisfactory classification of cases of penetrating wounds of the chest is one according to the behaviour of the patients under treatment. The first duty of the medical officer is to suture any sucking or blowing wound, so that all wounds may be considered as closed.

1. The lung is wounded, and both air and blood escape into the pleural cavity; some air may be sucked in from outside. Bleeding from the lung continues until the increasing pressure of the hæmopneumothorax and the displaced mediastinum causes a degree of collapse of the lung, when the hæmorrhage ceases. The elastic mediastinum which is displaced towards the opposite side, contributes its quota to the rising pressure, while the diaphragm rises and becomes immobile. The explanation of the behaviour of the diaphragm is obscure. Tudor Edwards believes it to be due to a patchy atelectasis in the lung. In my opinion it is a protective reflex, an attempt by Nature to put the injured part at rest, analogous to the inhibition of intestinal movement seen in abdominal wounds.

The balance is struck, and many patients from this moment begin to improve. In such cases after forty-eight hours the fluid is aspirated from the affected side, the pleural cavity being emptied down to the level of the eighth interspace in the scapular line. No attempt is made to aspirate the air, which remains as a buffer to prevent the too rapid reexpansion of the lung, which might cause renewed hæmorrhage. In some cases a second aspiration is required two or three days later, and this is due to the outpouring of pleural fluid as a result of the presence of irritating blood.

Temperature, pulse and respiration charts of such patients show an initial rise of temperature to 101° F., a pulse rate of 100, a respiratory rate of 26 (q.p.) and a gradual fall, so that at the end of seven days, temperature, pulse and respirations are in the region of normal.

2. In a number of cases a deterioration occurs in the condition of patients who appear to have struck their balance during the first twelve to eighteen hours. This is due to a rapid formation of pleural exudate, accounted for by a large primary hæmorrhage, severe laceration of the pleura, or perhaps a specially sensitive pleura. The pressure in the pleural cavity increases, the mediastinum is further displaced, and the patient goes into a dyspnœic crisis. Respiration becomes more and more laboured, moist sounds are heard all over the opposite lung, and death rapidly ensues. This is probably due to kinking of the cardiac stalk with pressure on the pulmonary veins. This crisis usually develops in the second twenty-four hours. The treatment is the administration of morphine and atropine and immediate aspiration. Provided a reasonably close watch is kept on the condition of the patient, the crisis can generally be anticipated, and aspiration will invariably avert it. Even in the actual crisis, aspiration will save the patient.

3. In a third class of case a balance is never struck. As soon as the initial shock is overcome and the blood pressure commences to rise, it is evident that the patient's condition is becoming worse. This is due to continued systemic hæmorrhage, usually from a wounded intercostal or internal mammary artery. Such arterial hæmorrhage, at a pressure four times as great as that of the pulmonary circulation, produces its signs and symptoms quickly. If the leakage is rapid, aspiration is useless; it merely provides more room for further bleeding. To my mind this is the one important indication for early operation.

Sometimes the arterial hæmorrhage is not sufficiently rapid to cause such an early crisis. Aspiration is done, with its usual beneficial results, but there is a comparatively rapid refilling of the pleural cavity. Further aspiration reveals that fresh blood is being poured out. Operation is the correct treatment.

4. The fourth group consists of those cases in which the patient suffers from a pressure pneumothorax. This is a comparatively rare condition, dependent on a valvular hole in the lung which allows air to escape into the pleural cavity, but does not allow of its return. Coughing is induced by the irritation of the communicating bronchus, and with each cough a quantity of air escapes into the pleural cavity. There is grave distress and dyspnœa, and the condition is often fatal. It has been stated that a pressure pneumothorax can be produced by a valvular opening in the parietes, air entering on each inspiratory effort, and building up a high pressure in the pleura. I do not think that pressure pneumothorax is produced in this way.

ANALYSIS OF CASES.

The cases under review may be analysed as follows:

	Number of Cases.	Number of Deaths.
Total number of patients with chest wounds	100	21
Both lungs wounded	3	2
One lung wounded	97	19
Number of patients evacuated to base	79	
Deaths due solely to chest wounds		7
Deaths due to chest wounds *plus*—		
Multiple other wounds		7
Abdominal wounds		5
Spinal cord transection		2
	Total	21

The seven deaths due solely to chest wounds were as follows:

Case XIII: Bronchopneumonia; patient survived for seven days.
Case XXII: Hæmorrhage from intercostal vessel.
Case XXIII: Bad patient, would not tolerate position or oxygen tube, repeatedly out of bed; survived six days.
Case XL: Five foreign bodies in one lung, severe shock; patient survived for five hours.
Case LVII: Pressure pneumothorax, mediastinal emphysema.
Case LXXIX: Pressure pneumothorax.
Case LXXXVII: Perforation of right lung, penetration of right auricle, tricuspid valve, foreign body embedded in wall of right ventricle; patient survived for eighteen hours.

COMMENT ON CASES.

Sucking Wounds.

There were forty sucking wounds. All were sutured except one (Case XL). This patient had several wounds in his chest, of which two were sutured, but a third, in his back, was missed. This patient died.

Of the 40 patients, 13 died: four were admitted to hospital moribund with multiple wounds, and died within four hours; four were nearly moribund with multiple wounds, but survived more than four hours; two had abdomino-thoracic wounds; two died of pressure pneumothorax, and one of hæmorrhage from an intercostal vessel.

It has been stated that suturing was nearly always done quickly in the resuscitation ward without formal excision. If the wound had been already efficiently sutured it was left undisturbed. In spite of this, in the 27 cases in which the patients survived, healing took place rapidly and without gross suppuration or necrosis of tissue. This remarkable result is presumably due to the complete perforation of the thin thoracic wall, which does not retain fragments of clothing or other infective material. The free circulation is a helping factor, as is also the comparative immobilization of the wound.

X-Ray Examination.

The X-ray service of the hospital is most efficient, and the apparatus is admirable. In spite of this only a small number of the patients had an early X-ray examination. The patients withstand movement and manipulation very badly, so that a complete X-ray examination is out of the question. In milder cases a quick screening was carried out and an antero-posterior skiagram was taken. In more severe cases examination was deferred until the condition of the patient was more stable. A survey then yields very useful information. The size and position of the foreign body (if any), the amount of blood and air in the pleural cavity, the position of the mediastinum and the diaphragm, skeletal damage to the thoracic cage—all these are important points.

In spite of this, it is my opinion that it is safer to defer the X-ray examination except in mild cases. All necessary information should be obtainable by ordinary clinical methods.

Clinical Examination.

Since we know how severely patients with wounds of the chest react to disturbance, clinical examination is reduced to a minimum.

1. Inspection: The affected side will be seen to move less freely than the unaffected side. The apex beat may sometimes be seen. Swelling may mark the site of surgical emphysema. Frequent and/or distressed respiration will be evident.

2. Palpation: The position of the apex beat will be found. This may be as far to the left as the axillary line, or as far to the right as to be clear of the right border of the sternum. Left-sided collections cause greater displacement of the apex beat than do right-sided collections. Absence of tactile vocal fremitus is a reliable sign that the lung and the chest wall are not in contact. This may be due to fluid or to air.

3. Percussion: The dulness of fluid and the hyperresonance of air are generally to be found. In some cases a hæmatoma of the lung will give a localized dulness.

4. Auscultation: The signs are liable to be equivocal, and their explanation is too controversial for discussion here. It is sufficient to remember that we are dealing with a wounded but otherwise healthy lung, and a perforated but otherwise healthy pleura. Ægophony is a reliable indication of the presence of fluid, but not of its quantity.

5. Blood pressure, hæmoglobin estimation *et cetera*: These investigations have not been systematically made. They give no particularly useful information and disturb the patient.

6. Abdominal rigidity. Abdominal rigidity may be present.

Aspiration.

Aspiration is carried out with the patient in a sitting position. Under local anæsthesia the needle is inserted in the scapular line in the seventh or eighth interspace, and coupled up with a vacuum bottle (Potain). The pleural space is emptied of blood down to this level. Unless under pressure, air is allowed to remain. In early aspiration unchanged blood is obtained; in later cases the blood is defibrinated.

Many patients, and particularly those who are in a crisis or are threatened with crisis, complain of a considerable amount of pain about the lower part of the chest in front as the level of the blood falls. This is particularly noticeable if the aspiration is rapid. Slowing of the rate of aspiration will to some extent relieve the pain. Only one patient showed any signs of collapse, and this was immediately relieved by stopping aspiration.

In cases with crisis or impending crisis there is a small degree of immediate relief, and this goes on until after about thirty minutes there is complete relief and the patient is very comfortable.

Fifty-six out of seventy-nine patients who were evacuated had their chests aspirated.

Pressure Pneumothorax.

The signs of the very dangerous condition known as pressure pneumothorax are not easily recognized. The patient is gravely distressed, the apex beat is notably displaced, and the percussion note is hyperresonant. Frequently there is blood-stained frothy sputum. The easiest and quickest and most reliable way to verify the diagnosis is to insert a wide bore needle into the second interspace about two inches from the sternum. Air under pressure will escape with a whistling sound. If this happens, the needle should be coupled with a rubber tube leading to a water seal bottle.

There have been only two cases of pressure pneumothorax in this series, and both have been fatal. In one there was a tear into the mediastinum, and the air preferred to escape by this tear rather than through the needle. The result was a gross mediastinal emphysema. I think that in this case the mediastinum should have been opened at the episternal notch. By the time I had decided to do this the patient was dead. The general condition at no time allowed of thoracotomy with a view to repairing the tear.

The second patient had several other wounds, and the general condition was bad. He was treated by needling as described, but did not respond.

Medication.

Every patient received sulphonamide. At first "M. & B. 693" was used, in the belief that the pneumococcus would be of importance. As this belief was not supported by the clinical results, sulphanilamide has been used for the past two months. The dosage is two tablets four times a day, but the first dose consists of four tablets, and the second of three tablets. This dosage is continued for ten days. Patients who are not allowed, or cannot take, anything by mouth, receive two grammes of sulphapyridine daily by intramuscular injection.

Evacuation.

In general, patients are evacuated after about ten days. A few have been retained for a longer period, and a few have been evacuated earlier. Those patients who are not going to pursue an uninterrupted course towards recovery usually show a rise in temperature in the second week. In view of this it would appear that the optimum time for removal of the foreign body—if this appears necessary—is at the beginning of the second week. In

this hospital I have not considered it advisable to proceed with deliberate chest surgery, and the patients are evacuated to base as soon as it is considered that they are fit to travel.

Operative Surgery.

Very few of the patients are in a condition to stand early operative interference. Only three early operations have been undertaken, apart of course from those necessary in the treatment of the abdomino-thoracic wounds. In each case the foreign body was removed, and convalescence was rapid.

In one case, owing to difficulties of evacuation, the patient had to be retained in the hospital for three weeks. His condition was deteriorating as the result of sepsis round a very large foreign body in the lower lobe of the right lung. This was removed, and the patient was evacuated in a satisfactory condition a week later. Fourteen other patients with chest wounds were retained for about three weeks at about the same time, but all were evacuated in good condition without operation.

Follow-Up.

During July I was able to trace a number of the patients with chest wounds who had passed through the hospital. Thirty-two in all were traced. There had been no deaths. Two patients had had empyema. Several had been discharged from hospital to convalescent depots. Major E. S. J. King had successfully removed foreign bodies from six.

It will be possible a little later to trace 100% of the patients evacuated from this hospital.

CONCLUSIONS.

1. Sucking wounds must be sutured and not packed.

2. Early operation is not often indicated. In my opinion only one of the patients who died could have been saved by operation.

3. A minimum of interference is advisable.

4. Aspiration should be performed whenever there is an appreciable amount of fluid in the chest (blood or other fluid).

5. Patients with chest wounds should be retained in forward areas for seven to ten days at least.

6. The optimum time for operation for removal of a foreign body, if necessary, is probably in the second week.

ACKNOWLEDGEMENTS.

I am indebted to Colonel W. A. Hailes for his help in tracing patients, to Major T. L. Tyrer for his excellent X-ray work, and to Captain A. J. M. Sinclair for his help in clinical examination of the patients.

SURGICAL EXPERIENCES IN THE MIDDLE EAST.[1]

By JULIAN SMITH,
Lieutenant-Colonel, Australian Army Medical Corps, Abroad.

THE surgeon about to undertake the treatment of wounded may be apprehensive that he will be faced with problems very different from those of civilian practice. The surgical problems are perhaps not so great as one would be prone to think. Nevertheless, they have to be dealt with under varying conditions and in an environment which at times, to say the least, is strange. The surgeon should realize at the outset that there are limits to the application of his craft, especially in the field. Unsatisfied as he may be in the beginning, he will soon learn that almost any wound can be dealt with adequately, with the use of the minimum number of simple instruments, for the sooner the surgical frills of private practice are discarded, the better. This paper deals briefly with the possibilities of surgery in the field and the conditions under which at times it must be performed. In addition, a few impressions are offered concerning wounds of special type.

The experience, by no means great, from which one draws, was gained during two periods of surgical work; the one, in January to March, 1941, in the Western Desert with a surgical team, the other with an Australian casualty clearing station during the campaign in Syria.

SURGICAL TEAM IN THE WESTERN DESERT.

The problems with which the medical services had to deal, cannot be appreciated unless the reader has some idea of the geography of the North African coast, and in particular the nature of the country of Cyrenaica.

West of Alexandria, one hundred and seventy miles, is the town of Mersa Matruh. At one time a seaside resort, about the size of Sorrento, it has been so persistently bombed that few of the buildings are habitable and the greater part of the present military population lives underground. It is connected to Alexandria by railway of limited capacity, both with regard to permanent way and rolling stock. Further west, seventy miles from Matruh, is the settlement of Sidi Barani which was literally reduced to rubble by the guns of the Royal Navy during the battle in December, 1940. The great escarpment of the North African coast approaches the sea at Sollum, a small fishing village about seventy miles from Sidi Barani. On the escarpment, a few miles inland and beyond the "wire" separating Egypt and Libya, is Fort Capuzzo—more a landmark than a fortification. From this fort the road leads back to the coast to Bardia, ten miles distant. Proceeding west about seventy miles, one reaches Tobruk, which is the first town west of Alexandria with a harbour of any size. The next coastal town of any importance is Derna, one hundred and twenty miles from Tobruk. Between Alexandria and Derna there are no villages or towns, except those referred to, which are worthy of the name. If the reader is to visualize the Western Desert, he must for the moment cast from his mind his idea of "country" as he knows it in the pastoral districts of Australia. From Alexandria to the foot of the escarpment at Derna there are few trees and little water. The country is a barren waste. Dust storms are frequent, and during the worst of them visibility is reduced to a few yards. Apart from these "khamseens", the

[1] Accepted for publication on December 1, 1941.

days were warm and pleasant, but the nights were bitterly cold. Fortunately there were few flies, for it would appear that even these pests are unable to live in such a country. On the escarpment above Derna the country improves and leads to the plateau surrounding Barce, which is attractive agricultural land. From there the country again falls off, and around Benghazi, nearly seven hundred miles from Alexandria, it is dull and unproductive.

Along this route, which marked the activities of a corps (of which an Australian division formed a part), the coast road is macadam. It was unfortunate that in parts heavy motor transport and other agencies had taken toll of the surface, particularly between Bardia and Mersa Matruh. The evacuation of wounded along this route was not only slow but became a nightmare for the wounded themselves.

It may be said that the battles of Bardia and Tobruk were the only formal engagements of the first Western Desert campaign, and it was during this phase of the advance that the great majority of Australian casualties occurred.

In December, 1940, Sidi Barani was captured. This was quickly followed by the fall of Sollum and Fort Capuzzo. About the New Year the Australian division moved and took up positions around the perimeter defence of Bardia.

The problems confronting those directing the medical services were considerable. An Australian casualty clearing station was established at Matruh by the New Year. From the description of the country, it may be guessed that there was no place further forward where it could have been sited with advantage and in the limited time. The aim of the medical service in war is to transport the wounded man to surgical aid with the least possible delay and thereafter, at the appropriate time, to expedite his evacuation in as safe and as comfortable a manner as possible to medical units in the rear. While medical men may have opinions as to the ideal method of achieving these aims, they should recognize the extreme difficulties which at times beset them and that often a compromise must be accepted. It would be well for some critics to realize that to some of the medical problems of warfare there is no adequate solution.

At the battle of Bardia an Australian surgical team was attached to the main dressing station of an Australian field ambulance near Fort Capuzzo, about four miles outside the "wire" or perimeter defence. All casualties passed through this main dressing station. The critically wounded were retained for treatment by the surgical team, while other casualties, after receiving the usual field ambulance attention, were passed on to a "light casualty clearing station" working below the escarpment a few miles from Sollum. From this unit wounded were evacuated over the unbelievably rough road to a casualty clearing station at Mersa Matruh, and from there by rail to base hospital at Alexandria.

Prior to the attack on Tobruk, a casualty clearing station had been established in a tented Italian hospital at Bardia. The surgical team moved up to a position somewhat similar to that occupied at Bardia, being attached to a composite main dressing station formed by two Australian field ambulances (Figure I). There was, however, a difference in disposition which greatly affected the evacuation of wounded. The main dressing station to which the team was attached, was sited about ten miles off the Tobruk-Bardia road. The connexion between main dressing station and main road was by desert track over which ambulances carrying wounded could travel no more than three or four miles in the hour. The tracks from advanced dressing station to main dressing station were of a similar nature, and it is due to this fact that, despite the relative proximity of surgical aid to the scene

of operations, some of the wounded were not admitted for twelve hours or more after receiving their injuries.

Some argument may be aroused if, at this stage, one briefly discusses the merits or even the necessity of operating on the wounded in forward areas. One believes that a primary function of the medical service is to assist in the evacuation of the wounded to a place of comparative quietude and safety, where they can receive surgical treatment and thereafter be held until fit to travel to base hospital. That the wounded man should receive treatment as soon as possible is beyond all argument. If tactical considerations have prevented a casualty clearing station from being reasonably accessible, then the critically and severely wounded must be dealt with at the main dressing station level. The surgical service should here be provided by a team sent forward, and not by the personnel of the field ambulance. Operations should be strictly limited to those who are severely wounded, the less severely wounded being passed back to casualty clearing station, distant though it may be. After a severely wounded man has been operated on, he must on no account be evacuated forthwith, but must be held until fit to travel without risk. This is no question of military tactics—it is a cold surgical fact. Therefore, in all forward operating centres provision must

FIGURE I. Showing main dressing station of two field ambulances at Tobruk, January, 1941.

be made for holding wounded for some days after operation. The practice of treating all wounded in forward areas, without discrimination as to severity, will lead to confusion. The greater the number operated on, the greater the number which must be held. Field ambulances are not equipped to handle large numbers of patients who have been operated on, and the addition of a surgical team does not adjust this deficiency. A field ambulance should never attempt to abrogate the functions of a casualty clearing station.

As the surgical team had had some surgical experience in the field at Bardia and intermittently prior to the battle of Tobruk, it was not unnatural that during the latter engagement it was perhaps seen to greater advantage. By this time organization was taking shape and one's ideas had become more defined. A description of the work done at this stage may be taken as an example not of the limitations but of the possibilities of surgery in the field.

The main dressing station was sited about five miles from the perimeter of Tobruk. As far as the eye could see there were no landmarks of any kind. At that time wide dispersion of tents and camouflage were considered preferable to prominent Red Cross markings as passive defence against hostile aircraft. This dispersion added considerably to the difficulties of working, and the duties of the stretcher-bearers were particularly arduous.

The theatre was an Italian operating tent about 12 feet by 8 feet. The floor was aluminium and skylights provided good illumination. Windows were

celluloid in wooden frames, and were covered with an inside and outside flap to provide protection against dust. Although reasonably efficient, there is no tent which can be made dust-proof against the "khamseens" of the Western Desert. The operating tent contained operating table (Australian Army pattern) and its metal case resting on its open doors was used as an instrument table. A box in one corner, for use as the anæsthetist's table, completed the theatre furnishing. The operating tent possessed a porch as an integral part. To this porch an "R.D" tent was brigaded and used for storing panniers. It was also a convenient parlour for personnel of the team, in which meals could be served and where a few minutes' rest could be obtained between operations. Entrance to the operating centre was through this

FIGURE II. Showing forward operating centre of Australian surgical team at the battle of Tobruk, January, 1941.

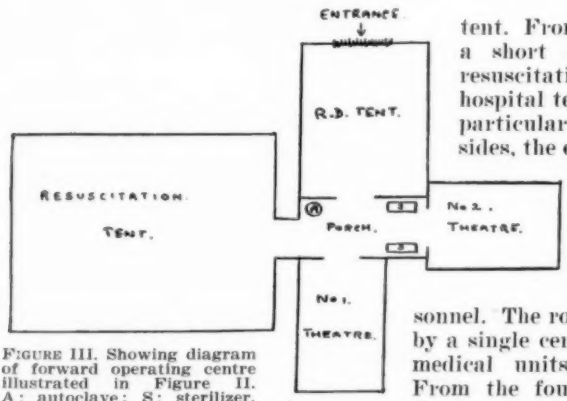


FIGURE III. Showing diagram of forward operating centre illustrated in Figure II. A: autoclave; S: sterilizer.

tent. From a third side of the porch, a short covered way led to the resuscitation tent—an Italian field hospital tent 24 feet by 18 feet. This particular type of tent has double sides, the external ones being sloping and the internal vertical. The space between inner and outer sides is handy for the storing of equipment and may be used as sleeping room for personnel. The roof of the tent is supported by a single centre pole. For use in field medical units this tent is excellent. From the fourth side of the porch a short covered way led to another operating tent. The entrance to the unit was the "R.D." tent (Figures II and III). Around the operating centre, dispersed at about one hundred yard intervals, were four "E.P.I.P." tents for patients who had been operated on. All wounded were of course accommodated on stretchers, for a limited number of which trestles were available.

Water was brought to the main dressing station each morning from a point about ten miles distant. The theatre supply was stored in a forty-four

gallon drum and siphoned out as required. At one period the supply was dark brown with a very heavy sediment, but this was effectively cleared by a small hand-worked Italian filter pump of multiple candle type.

During the two major engagements the team was fortunate in being supplied with electric light by the field ambulance from small motor-generator units. At other times, particularly while work was being done near Benghazi, the light provided by Tilley lamps, torches and the like was quite inadequate and rendered work rather difficult.

Personnel of Team.

The team consisted of surgeon, assistant, two operating room assistants, an anæsthetist orderly and batman. A surgical team should not be chosen without due deliberation. As it is obvious that one man and one man only must be in command of the team, he should be some years senior to his assistant both in regard to age and experience. It is not so much a matter of his orders being obeyed as it is a question of his decisions being accepted without discussion. If this discrepancy in age and experience exists, there is never any doubt as to who is the head man and who is the "stooge". A surgical team so chosen will usually work more smoothly than one in which the medical officers are contemporaries. The ideal type of assistant is one who has been qualified for some three or four years, who has done general hospital work and who has surgical leanings. During the Western Desert campaign the writer was fortunate in having Captain (now Major) Douglas Stephens as his assistant. Any success which the team may have achieved was due in no small measure to his diligence and very able assistance.

The duties of the assistant, succinctly described, are to "tee-up" cases, to administer difficult anæsthetics, to assist with resuscitation and generally to act as an all-rounder.

While the casualty clearing station was working in Palestine in 1940, several orderlies were instructed in anæsthesia, and one of these accompanied the surgical team. He proved very efficient and no deaths occurred which could be attributed to mistakes on his part. When, as happened on one occasion, the writer was working two theatres, the dental officer of the field ambulance acted as second anæsthetist. A specialist in anæsthesia in a surgical team is a misplaced and wasteful member.

The operating room assistants had had previous experience in theatre work in the army. They were responsible for the sterilizing of instruments, linen, swabs and dressings, for the preparation of sutures and for the setting up of the theatre; in addition they assisted at operations.

A batman is an essential member of a surgical team. His time is fully occupied, as in addition to his usual duties he has to forage meals at odd hours, to make hot drinks for the team and to do all manner of jobs. His inclusion should not be regarded as a luxury; it is a necessity.

General Theatre Organization.

A limited quantity of sterile wool, gauze and dressings was taken up from the casualty clearing station. This was quickly expended and thereafter at Bardia the team relied for sterilization on autoclaves in the possession of the field ambulances. After the fall of Bardia, the team "acquired" a small Italian autoclave which fulfilled all requirements most admirably. When dismantled, it is packed in two panniers, each of which can easily be handled by two men. Heat is supplied by a large "Primus" burner. The autoclave accommodates three ten inch by five inch sterilizing drums. An autoclave of similar capacity should be included in the equipment of every surgical team, as it is unwise

to rely on the suggestion that supplies of sterile dressings may be sent forward from medical units in rear.

Various sets of instruments were assembled in linen bundles. The one most frequently used was known as the "general set", and with it one dealt with the common type of battle casualty—for example, compound fractures, wounds of the limbs and non-penetrating wounds of the trunk. It was found possible to assemble three of these sets from the instruments in possession of the team. Each bundle contained a scalpel, scissors, toothed and plain dissecting forceps, probe, bullet forceps, towel clips, pair of retractors, six Spencer-Wells artery forceps, two pairs of Morison and Lane tissue forceps and a Volkmann spoon. These instruments suffice for the great majority of battle casualties. When an operation was concluded, the instruments were cleaned, rebundled and thrown into the fish kettle. A fresh set was always in readiness for the next operation. Similarly, "head", "amputation" and "abdominal" sets were assembled, each containing the additional instruments required for operations of this nature. In this way the team quickly worked into a routine which eliminated the usual delay associated with the change over from one operation to another which one is accustomed to accept as inevitable in general hospital practice. The use of gowns and gloves was restricted to abdominal and head cases, but gloves were worn for self-protection when septic wounds were being dealt with.

If a number of severe casualties are waiting, much time can be saved if the surgeon works two tables, when it will be found that the delay between operations is avoided. During busy periods there should always be a patient on each table. The surgeon is attending to one, while his assistant is preparing the other for operation. This preparation takes time and is very tiring, even exasperating. Clothing has to be removed.[1] Dressings and splints have to be taken off, the area shaved, cleaned and prepared. During the Syrian campaign this principle was followed in the casualty clearing station. Three surgeons were available. One would be operating, one "teeing up" cases and the third would be off duty. One is convinced that a surgeon, properly assisted, working two tables, can deal with a greater number of cases in a given time than can two surgeons working a table each in the same theatre.

Anæsthesia.

Ether was the anæsthetic most frequently used and preferred. It was administered by an orderly or by a dental officer. One found no place for spinal anæsthesia. "Pentothal Sodium" was used extensively and proved to be a wonderfully convenient anæsthetic for short operations. Its sulphur content did not appear to be incompatible with the large doses of the sulphanilamide compounds which the wounded received. The surgical team relied, therefore, on ether and "Pentothal Sodium", and it is believed that no patient suffered through lack of gas and oxygen anæsthesia.

Resuscitation.

The traditional methods of providing resuscitation were adopted. The only comments which one wishes to make at this juncture concern the merits of dry plasma (or serum) and blood transfusion. First let it be said that, whether or not surgical teams are employed in forward areas, facilities for resuscitation (including intravenous methods) should extend at least to main dressing stations and sometimes to advanced dressing stations and mobile sections. It is only on occasion that a wounded man requires immediate operation, but he may be in desperate need of blood transfusion.

[1] Wounded brought in during the night at Bardia usually wore "jerkin", greatcoat, tunic, one or two sweaters, shirt and singlet.

It has been previously stated that at the battles of Bardia and Tobruk the surgical team had the responsibility of dealing only with those who were seriously wounded. It followed, therefore, that many of these men needed resuscitation, and in fact 33% of those operated on at Tobruk received transfusion of blood. In all, about forty pints were used. The surgical team during this period was fortunate in having the responsibilities of resuscitation undertaken by Lieutenant-Colonel Ian Wood. The day before the battle, blood was collected from Group II and Group IV donors. These were drawn from the usual sick wastage, from walking wounded which were passing through the main dressing station, the latter having received their wounds on reconnaissance, from booby traps and stray shells. The blood was stored in an ice box which had been brought up filled from Alexandria. As this blood was used, the store was replenished from time to time from the walking wounded who passed through the main dressing station during the battle. The "Soluvac" system was used, and there is no doubt that it won its spurs. It is essential that, whether in a surgical team or not, the medical officer in charge of resuscitation should be technically expert in blood transfusion. It is one thing to perform a transfusion in a public or private hospital, where everything is handed out "on a plate". It is quite another thing to give a transfusion rapidly to a patient and without a hitch by the light of a Tilley lamp in a tent, with none of the accepted hospital amenities, surrounded by men who are dying and by others who need blood as soon as it can be given. At one time at Tobruk six transfusions were being given simultaneously. A surgical team loses a great deal of its efficiency if it lacks the services of a good transfusion officer. In the opinion of the writer a third member should be added to all surgical teams operating at the main dressing station; the duties of this officer should be those of resuscitation, before and after operation.

This method of taking blood immediately before the expected time of arrival of casualties was practised in the casualty clearing station during the Syrian campaign. During the writer's association with battle casualties over one hundred transfusions have been given to wounded who, although not all under his care, have been observed. There was no serious complication which could be directed at blood transfusion. If, however, this method of building up miniature blood banks be adopted, each bottle must be very critically examined before the blood is given. Speaking arbitrarily, one would hesitate to use blood over three days old.

Of the merits of dry plasma (or serum) one cannot speak with authority. As with therapeutic novelties in general, dry plasma is regarded in some quarters as an elixir. One hears reports that "200 cubic centimetres of plasma were given" and that no appreciable improvement was noted.

The dry serum or plasma is a yellow crystalline powder, supplied in ten-ounce bottles. Each bottle contains the dried solids from 200 cubic centimetres of human serum. This is reconstituted by adding sterile water from a companion bottle up to 200 cubic centimetres. Neglecting the replacement of oxygen-carrying capacity which transfusion of blood effects, what degree of hydrostatic benefit would an exsanguinated patient derive from transfusion of a paltry 200 cubic centimetres? If dry serum or plasma is used as a substitute for blood when the patient really needs blood, then it is futile to give less than three bottles. It will prove useful in tiding the patient over a critical period until correct restorative measures and surgical treatment can be provided, but it cannot be expected to prove adequate as a substitute for blood in a man who has suffered severe blood loss. It has the great advantage that, being obtained from pooled blood of all groups, it can be given indiscriminately without typing of recipient. Furthermore, it carries without refrigeration and the technique of infusion is simple.

GENERAL TREATMENT OF WOUNDS.

Débridement.

Periodically, the word *débridement* has carried varying implications. At the present time, to some surgeons it means nothing more than the removal of organic matter and foreign bodies from the wound with forceps. An interpretation which leads to the employment of more radical measures is that in addition the wound edges and all dead tissue should be excised. Furthermore, one is under the impression that, used in its original sense, the word *débridement* implied the provision of adequate drainage, for this is a most important item in wound toilet that must not be neglected.

In planning the treatment of a wound the surgeon must attempt to reinforce his visual perceptions with a picture of the probable state of the wound in a few weeks' time. Excision of the edges and omission of suture will not provide adequate drainage of the cavity in a limb if the only exit is through a small hole in the deep fascia. The size of the wounds of entrance or exit is no criterion of the destruction which has been caused in the deep tissues, especially if the missile has impacted on bone. In all penetrating wounds, therefore, the deep fascia must be split and even incised against its fibres and the depths of the wound explored. If the surgeon adopts this practice he will receive many surprises. It is sometimes difficult to decide when a wound has passed the stage at which *débridement* will be effective. Wounds some days old are better dealt with less radically than those of recent origin. All obvious fragments of loose bone, foreign bodies, dirt and organic matter are of course removed. The surgeon should then be content with providing drainage along the lines advocated. Wounds seen at this stage are infected, if not actually suppurating, and natural defensive barriers are doubtless being erected. If such wounds are excised, all that will be achieved is the production of another suppurating wound of larger size.

Sulphanilamide.

Four tablets of "M & B 693" were given to all wounded on admission, and this was followed by two tablets every four hours. It was the practice of some field ambulances to give a large initial dose of ten tablets and a single daily dose of equal amount is the routine in some base hospitals. There is no doubt that the single daily dose solves a domestic problem of no small order, when in a casualty clearing station the drug has to be given to a large number of patients by a limited staff. The sulphanilamides have been used on all open wounds. A mixture of "M & B 693" and sulphanilamide tablets was crushed and used for local application. The mixture was employed because of the apparent selective action of the two drugs on different anaerobes. Pure "M & B 693" or sulphanilamide powder is preferable to the crushed tablets, as the latter contain starch and acacia used as excipients. The aim of the surgeon should be to instil the powder into the depths of the wound. If wounds are laid open, as they should be, this is a simple matter. Skin edges and fascia are retracted and a Volkmann's spoon filled with powder is introduced into the depths of the wound and then inverted. The surface is sprinkled with powder and then covered with a generous smearing of "Vaseline".

Of the value of the sulphanilamide compounds one is convinced beyond all doubt. Among the 1,500 battle casualties treated during the Syrian campaign there were seven cases of gas gangrene. All of these were established infections on reaching the casualty clearing station. In all, the spread of infection was checked after appropriate surgical treatment. No case of gas gangrene developed in the casualty clearing station or in any of the casualties

after their evacuation to base. These facts are inconsistent with the picture of gas gangrene as one knew it prior to the introduction of sulphanilamide. Whether this drug and its derivatives act directly on the anaerobes or whether they limit the growth of streptococci upon which the anaerobes are symbiotically dependent, cannot be stated. It is enough that the use of sulphanilamide locally and generally combined with adequate surgical treatment has changed the picture of the wounds of war.

The "'Vaseline' Pack".

The unfortunate use of the term "'Vaseline' pack" has led to confusion. Winnett-Orr, in his original contribution, suggested that after the wound had been shaped to allow it to drain adequately, it should be lightly packed with "Vaseline" and gauze. In some quarters the word "pack" has been accepted as a synonym of "plug", and on many occasions one has seen wounded arrive with their wounds tightly plugged with a large piece of gauze and even with the edges sutured. One remembers a man wounded by a large fragment which entered the left iliac fossa, passed through the innominate bone and emerged through the buttock without entering the abdominal cavity. A large piece of gauze had been inserted from entrance to exit wound, passing of necessity through the hole in the bone. Major Somerset has informed the writer of two cases of compound fracture of the femur in which gauze packing had been similarly employed, in both cases actually passing between the fragments. These men, on arrival at the casualty clearing station, were in great pain, were running hectic temperatures, and were critically ill. The removal of the packing, an extremely difficult procedure, was followed by a gush of pus and the patients' condition rapidly improved.

While the use of packing and even suture cannot be denied to medical officers as a temporary measure to control hæmorrhage, the adoption of such a method as a formal surgical procedure cannot be too strongly condemned.

The wound toilet then consists in the performance of *débridement* as described, instillation of "M & B 693" powder, and the application of a large blob of "Vaseline" to the wound, which is then covered with several layers of gauze as a flat dressing.

Plaster.

All compound fractures were enclosed in plaster if this medium was deemed effective in securing immobilization. Some large muscle wounds were similarly immobilized. There need be no concern about the adoption of this practice, which at one time would have been labelled as at least unorthodox, provided the wound has been treated by thorough *débridement* and drainage and has not been packed with gauze. So much has been written about the so-called closed plaster method that further comment would be superfluous.

REGIONAL SURGERY OF WOUNDS.

The remarks which follow are based primarily on experience gained with the surgical team in Cyrenaica. The work of this period was followed by that in the casualty clearing station during the Syrian campaign under conditions which permitted greater surgical deliberation. The conditions under which the work of these two periods was carried out were as wide apart as the poles. If the one was associated with certain surgical privations, though tiring, it was never tedious. The other, perhaps, enforced the conviction that there is nothing difficult about the surgery of war wounds. A surgeon who has passed successfully through the mill of emergency surgery at a general hospital can face the wounds of war with equanimity. He will at times be disappointed that men die. But the missiles with which they have been

maimed are designed to kill. And so they do. The fact must be accepted that the damage to the body is often irreparable. One might imagine that the average war wounds are large and terrifying affairs. On the contrary, the majority might be described as quite minor. The occasional horrible extensive mutilations in men who survive to reach surgical aid are the exception and are but a tribute to the resources of Nature and the fortitude of man. Rather than attempt to achieve the impossible, it is better that the surgeon should turn his efforts to the treatment of those who will probably survive.

Wounds of the Abdomen.

One has chosen to comment on these wounds, for, although they are a source of great disappointment, at the same time they provide some of the dramatic episodes of war surgery. The number of these wounds which have been treated is very small. Nevertheless, the experience of these few operations, the majority of which were performed in a tent in the Western Desert, has been sufficient to convince the writer that, were it not for their comparative rarity, they would constitute one of the major problems of the medical service in war.

There is nothing subtle about the gunshot wound of the abdomen. The clinical picture stands out from that of other casualties in stark relief. The wound of entry may be not only in the belly or back, but in the thorax or buttock. Sometimes protruding omentum or intestine leaves one in no doubt that the peritoneum has been holed. Apart from the local signs, the wounded man usually presents the most obvious signs of exsanguination. When a missile enters the peritoneal cavity, it is inevitable that a vessel of some size is wounded, and it is through the medium of the resultant hæmoperitoneum that intestinal contents are rapidly and widely dispersed.

The early clinical signs of a penetrating wound of the abdomen are no different from those of any acute perforation, and they depend as much on the extravasation of blood as on the spilling of intestinal contents. The frequency of massive intraperitoneal hæmorrhage associated with these wounds may be gauged from the fact that among the 18 cases received by the surgical team 13 patients required blood transfusion. Wounds of the colon combined with a wound of a vessel of any size are therefore unlikely to be followed by recovery.

It is obvious that these wounds must be dealt with as soon as possible. If a casualty clearing station is reasonably accessible, they provide perhaps the only justification for forward operating teams. The fact that such a unit is, in terms of distance, near the battle area does not mean that it will receive casualties within a reasonable time. Despite the relative proximity of the main dressing stations to the firing line in the Western Desert, the team received two men with abdominal wounds more than twenty hours after they had been wounded. The delay, if the elapse of time can be so described, in the evacuation of wounded is usually not between main dressing station and casualty clearing station, but occurs between the time the man is wounded and his arrival at the main dressing station. If forward operating teams are available, then naturally the abdominal wounds should be operated on in these units. If not, the wounded should be evacuated from field ambulances with all speed, as it is futile to wait for a satisfactory response from resuscitation in the main dressing station, as, although it may be forthcoming, it is short lived. Benefits must be balanced against risks. The patients, therefore, should receive blood or dry plasma, and be evacuated forthwith, despite the fact that their general condition may be unsatisfactory. No matter how soon some patients with abdominal wounds are operated on, they will not survive.

The Operation.—In gunshot wounds of the flank, in which injury to the kidney is likely but intraabdominal injury problematic, a transverse incision may be used. This is designed primarily to afford approach to the kidney and structures in the loin, but the peritoneal cavity may be opened and an adequate exploration of the viscera in the vicinity can be made. However, in the great majority of cases of abdominal wounds a mid-line incision should be employed, upper or lower according to the region of suspected damage.

As previously stated, there is invariably blood in the abdomen, and the condition in which the wounded man is admitted testifies to the amount which one may expect to find. The removal of this blood and clot is the first step in the operation, and this is best achieved by mopping with large packs (face washers are excellent substitutes). A large hæmoperitoneum cannot be evacuated with a sucker. Despite the alarming amount of blood which has been shed, it is unlikely that one will succeed in displaying the vessel which has been torn, even if the liver or spleen has been lacerated. Once the blood has been mopped out, the search for perforations is commenced. The small intestine is examined first, a start being made either at the ileo-caecal angle or the duodeno-jejunal flexure. This inspection must be systematic. As each coil is brought up to the abdominal wall, a decision must be made and that decision must be final. The surgeon should satisfy himself once and for all about the condition of the loop which he is examining, and if repair or resection is necessary, he should perform it before proceeding with the inspection of the remainder of the bowel.

There is little fear of overlooking a perforation. The mucous membrane of the intestine is everted, and for some distance on each side the bowel is dilated, its wall œdematous, and its coat shaggy. Before the perforation is closed it is wise to display the integrity of adjacent bowel and mesentery. Unless this is done the surgeon may find that later he is forced to resect a segment of bowel which he has just spent some time in repairing. Small perforations may be safely closed with a single "Z" purse string of linen thread.

At times the perforation is large, the bowel being almost completely divided. In this case, rather than to attempt the usual closure, it is wiser to complete the division, trim the ends and perform anastomosis.

The indications for resection are usually obvious and depend on the extent of injury to the mesentery no less than that to the small intestine. When multiple perforations are present it is often wiser to resect that segment rather than attempt to repair each individual perforation. It will need few cases of intestinal anastomosis to convince the surgeon that the traditional methods of civilian practice have no place in war. End-to-end anastomosis may be safely performed with a single layer of linen thread. The needle is passed from within the lumen of the bowel through all coats, and satisfactory invagination is obtained. Linen thread was used exclusively for all intra-abdominal ligatures and sutures.

Perforation of the large intestine associated with a hæmoperitoneum of any size will usually prove fatal. The condition is somewhat analogous to the acute perforation of a sigmoid diverticulum, but the larger size of the hole made by the missile allows an almost explosive ejection of fæcal contents, which are all too rapidly and widely disseminated by the blood which floods the belly.

After the repair of intraabdominal injuries, the closure of the abdomen and the question of drainage must be considered. One has never been able to accept the suggestion of through-and-through silkworm gut sutures, as the best method of restoring the parietes. Very few patients who survive penetrating wounds of the abdomen enjoy a smooth convalescence. Gross

post-operative distension to the point of established ileus is the rule. There can be no doubt that an abdominal wall restored in the orthodox manner is better able to withstand the strain than one in which the edges of the wound have been crudely approximated with a single layer of sutures. Little time is consumed in suturing the peritoneum and aponeurosis in layers with continuous catgut and inserting a few silkworm gut sutures in the skin.

It may appear somewhat of a paradox that the scope of the drainage tube is very limited in wounds of the abdomen. It has surely been proved that diffuse inflammatory exudates cannot be effectively drained from the abdominal cavity. It is, however, reasonable to insert a drain tube in the flank where there has been a localized bowel perforation, but it is probable that the drainage tube contributes little to the recovery of any penetrating wound of the abdomen.

Post-Operative Treatment.—The post-operative course is usually complicated by distension and sometimes unfortunately by persistent ileus. The use of the Rehfuss tube and intravenous administration of fluid are imperative. It is interesting to record the stormy passage through which one man passed on the road to recovery.

A gunner received a shell burst in the left flank. In addition to several minor perforations there were three almost complete tears of the small intestine. These were all converted into complete divisions, the ends were trimmed and a triple anastomosis was performed. Prior to operation he had received two pints of blood. The day after operation his abdomen was distended and he was vomiting. A Rehfuss tube was inserted and intravenous administration of dextrose-saline solution was commenced. Five days later, while there were still eight patients in the holding tents, the surgical team was ordered into Tobruk. Rather than evacuate these patients over the long rough route to Bardia, it was decided that they should accompany the team. The four who were most seriously ill left in an ambulance in charge of Lieutenant-Colonel Ian Wood, and they included the patient under discussion. The intravenous drip was working, the Rehfuss tube being still in place. Losing its way in the oncoming darkness, the party spent the night on the escarpment. The ambulance arrived in Tobruk the next day about eighteen hours after it set out on the trip. The patient still retained the Rehfuss tube in comfort and the intravenous drip was working. This man received a total of twenty pints of dextrose-saline solution and undoubtedly owes his life to the infusion. He was seen in Alexandria some months later well on the road to recovery.

Results.—This series of abdominal wounds is insignificant, including as it does but 23 cases under the writer's care. Nineteen of these were encountered in the Western Desert and were dealt with in an atmosphere which the writer has attempted to portray. Four men died without operation. Despite resuscitation, their condition never improved enough to warrant taking them to the theatre. In one, several feet of dark intestine were protruding through a hole in the abdominal wall about the size of a saucer. Death occurred about an hour after admission. Another of those who failed to respond was found at autopsy to have a torn *vena cava*.

Nineteen wounds of the abdomen have been operated on, and one can record only nine recoveries. As previously stated, the surgical team was located close to the battle area. Despite this fact, it was often ten hours before the wounded reached the operating centre, and two of the patients who died were not received until twenty hours after being wounded. Thirteen of those operated on required blood transfusion, which usually exceeded a pint.

The number of cases is too small to constitute even an average series. Perhaps with a further twenty cases the mortality would be higher. It is even possible that more favourable results might be obtained. But if the small series under discussion represents an average, then a penetrating wound of the abdomen is a formidable affair, and recovery cannot be expected in more than half the cases.

A survey of the fatal cases reveals the fact that in less than half could a good prognosis be given by the most optimistic observer. Two patients died on the operating table.

Of these, one had a large perianal wound and was profoundly collapsed. As his condition failed to improve, despite the usual measures, he was taken to the theatre and his abdomen was opened. There were multiple wounds of the rectum, which was gangrenous, the pelvis was filled with a mixture of blood and fæces, and the superior hæmorrhoidal artery had been divided.

The other immediate death occurred in a man with an associated chest wound. A third fatality was that of a man with a wound of the rectum.

The missile having entered through the buttock, the patient subsequently developed gas gangrene, which was checked by ruthless excision of the gluteal muscles. The post-operative period was complicated by severe and persistent ileus; and although the manner in which he was handled during his last days must be described at least as unsatisfactory, he died on the eleventh day with a burst abdomen.

An infantry subaltern, requiring resection of the small intestine and closure of several wounds of the colon, had reached the team twenty-two hours after being wounded. It subsequently transpired that the ambulance in which he was being transported ran off the road, down a steep bank and overturned.

A gunner received his wounds when his truck ran over a land mine. He required four end-to-end anastomoses, closure of perforations in the colon, amputation of the penis and plaster for a fractured ulna. It is rather remarkable that he lived for five days.

An ambulance driver, machine-gunned from the air while playing soccer, sustained wounds of the stomach, kidney and pancreas. Autopsy revealed gas gangrene of the abdominal cavity and its parietes.

One could never be optimistic in dealing with cases such as these, and in the fatal cases all the patients with one exception had multiple and severe injuries. It would be unjustifiable to express any definite opinions about these penetrating wounds of the abdomen, but it may be said that: (i) They form rather less than 1% of battle casualties which reach a main dressing station. (ii) The majority are associated with a hæmoperitoneum of large size. (iii) Wounds of the upper portion of the abdomen are apparently less critical than those of the middle or lower part of the abdomen. (iv) Wounds of the large intestine are associated with a very high mortality.

Chest Wounds.

It might be thought that penetrating wounds of the thorax constituted a serious problem in war surgery. Certainly they are serious enough and many of those dying on the actual field of battle succumb because of injury to the vital intrathoracic structures. Penetrating wounds of the thorax in patients who reach the main dressing station are, however, on the average not so serious as abdominal wounds and recovery is much more frequent. The simultaneous involvement of both cavities is not uncommon, but there is no doubt that the importance which these dual lesions assumed in the surgical literature of World War I is undeserved in the light of surgical experience in the present conflict.

One had read of large wounds of the thoracic cage reaching the casualty clearing station which demand immediate and expert treatment; of spleens and kidneys removed; of stomachs and colons repaired, through holes in the diaphragm; of injuries to the lung to be saved only by formal thoracotomy. It is apparently to deal with these emergencies that a casualty clearing station equipment contains two lung tourniquets and an inordinate number of Duval's forceps. From a pooled experience of the last war, the collection of these rarities would no doubt constitute quite a series. It is unfortunate, for the writer at any rate, that the literature has provided an impression of wounds of the thorax, and of abdomino-thoracic wounds in particular, which is false to a degree. It is not far from the truth to say that the immediate problem of an abdomino-thoracic wound lies in the abdomen

and it is the contents of this cavity which should receive priority. One can see no earthly reason why an attempt should be made to deal with intra-abdominal injuries via the thorax simply because the missile entered through this cavity. The surgery of the thorax has made great progress during the past decade. However, advances in the surgery of any particular region in peace time do not necessarily enhance the treatment of wounds of this region in war. It is not unnatural that the specialist will be wont to apply his skill to wounds of that region which his practice embraces. Unfortunately, perspective often becomes dimmed by excessive enthusiasm.

There is the true story of the surgeon well trained in the niceties of civil thoracic surgery, in charge of an operating team, who had apparently seen little of the ravages of war. In the course of conversation with a member of the writer's unit, he stated his intention to operate on chests as far forward as possible, moving quickly from place to place; such excursions, he anticipated, the mobility of his unit would allow him to make. He was asked with whom during the course of his thoracic barnstorming he would leave the patients on whom he had operated. He answered that they would be billeted in farmhouses and the like, and left to the tender mercies of the occupants. By what happy chance had a knowledge of surgery been widely disseminated through the peasants of Syria? What strange nomadic taint prompted such an outrageous proposal? The awed silence which followed was broken by an enquiry from this surgical gypsy: "How many lobectomies has Major Smith done?"

The thoracic specialist will find little to do either in forward operating teams or casualty clearing stations, and, moreover, it is very doubtful if any surgical specialist can justify his position in these units. It may be said that, with a maturity conferred by wider experience, opinions will be changed. Nevertheless, one feels that the foundations upon which these statements rest are unassailable. During the Cyrenaican and Syrian campaigns about 2,500 battle casualties passed through main dressing stations and the casualty clearing station where the writer was working. Not one solitary operation was performed primarily to deal with injury of the intrathoracic structures. It may be argued that the final results of the chest wounds encountered (and they were many) would have been better if, at times, formal thoracotomies had been practised. On the contrary, the mortality of these wounds treated conservatively has been strikingly low. In addition, Colonel Hailes has been particularly impressed with the infrequency with which he has met cases of empyema during his rounds of base hospitals in his role of consulting surgeon. Major Edgar King tells the writer that in 63 cases of penetrating wounds of the chest which have come under his care at base there have been only three examples of empyema.

In the treatment of thoracic wounds, whether in forward operating teams or in casualty clearing station, the keynote is conservatism, and the history of these injuries handed down from the last war will have to be rewritten.

Wounds of the thoracic cavity may reasonably be placed in one of three groups: (i) complicated, or abdomino-thoracic, in which the thoracic injury is subservient to the abdominal; (ii) simple, usually with hæmopneumothorax of varying degree; (iii) sucking, with open pneumothorax or internal valvular pneumothorax.

The first group has been briefly discussed and, in passing, it may be mentioned that four of the cases of abdominal wounds described were of this nature. The second group embraces the common through-and-through chest wound and those which are "uncomplicated", but with retained foreign body. These wounds are relatively common, and although the clinical manifestations are usually obvious they are not necessarily severe. Among the 1,500 casualties dealt with during the Syrian campaign there were between 30 and 35 of this type. The exact number cannot be assessed as "A. and D." diagnosis is excusably inaccurate, and in few of these cases do patients reach the operating theatre for treatment. In these patients there is a pneumothorax and/or

hæmothorax of varying amount. The extent of mediastinal displacement and respiratory embarrassment is noted and evacuation of blood and air is effected at the appropriate time. Aspiration, when performed, often yields large quantities of "blood". The writer's interest was aroused as to the extent to which the general circulation was depleted by these hæmorrhagic effusions. Even after three aspirations of a litre of fluid, the "hæmoglobin value" of the fluid was as high as 60%. The anæmic condition of some of these patients during convalescence, at times to a degree requiring transfusion, is but a reflection of the amount of blood which is actually lost in these recurrent effusions. Although in the end recovery is to be expected, the clinical course of these chest wounds is unpredictable.

The above remarks apply without modification to those cases in which the foreign body is retained. In these the patients should be treated conservatively in the casualty clearing station, and the writer yields to no one his opinion that if the foreign body requires removal, operation should be delayed until the patient reaches a base hospital.

"Sucking" chest wounds demand immediate attention, and one is most emphatic that the place to close these wounds is in the regimental aid post. A few silkworm gut sutures should be passed deeply and tied firmly. No anæsthetic is necessary. The medical officer must be convinced that the opening has been closed. In the past it has been the practice to attempt to seal these openings with dressings and strapping. Apart from the liability to displacement and consequent recurrence of sucking, this is an inefficient method of controlling these wounds. Five men with sucking chest wounds were admitted to the casualty clearing station during the Syrian campaign. The nature of these wounds had been recognized in forward medical units, and dressings had been strapped over the openings. The state of persistent open pneumothorax became evident when the dressing was examined or, on two occasions, when the position of the patient was changed. If efficient closure has been performed by suture in forward units, then wounds designated as sucking chests are better left undisturbed in the casualty clearing station, despite the retention of a foreign body.

Head Wounds.

It has been said that wounds of the head do not mix well with other casualties in the rota for operation. It is also undoubtedly true that the mortality from head wounds is distinctly lower in the hands of those who understand them. Therefore, the attachment of an intracranial surgeon to a casualty clearing station should at times prove profitable, but only workable if he is accompanied by his team. The hare and tortoise combination of general and neurological surgeon working side by side in the same theatre would be short lived. It is better that the latter should be given the scope for deliberation which he requires, in separate theatre and wards away from the hustle and bustle of the general theatre.

At times, however, it falls to the lot of the general surgeon to deal with head wounds. He must decide, with the equipment at his disposal, how much he should attempt. He will be wise if he limits the extent of his interference and is content to treat these cases in a simple manner. All wounds of the head should be examined by X rays if it is possible to do so. This will prove of inestimable value in revealing the extent of damage to the cranium both in entrance and exit wounds, the position of driven-in bone fragments, and the location of foreign bodies. The surgical team worked in Cyrenaica without X-ray apparatus, and the sense of added security which radiological evidence afforded during the Syrian campaign was considerable. With few exceptions, all wounds of the head, after being examined by X rays,

should be examined in the theatre. Despite the absence of fracture, meticulous attention should be given to the toilet and suture of the wound. The writer's practice, as a rule, was to treat penetrating wounds of the head purely as compound fractures of the skull; that is to say, attention was focused on the wound rather than on the clinical manifestations of the injury, which latter were often indications of irreparable damage. After the scalp has been shaved and prepared, the wound is excised and enlarged until the defect in the skull is clearly defined. All loose bone is removed and the cranial defect is enlarged until intact dura can be demonstrated around the circumference of the hole in the skull. The area is then gently irrigated and the track gently probed for loose fragments if their presence has been revealed by X-ray examination. Repeated quiet irrigation of the track at its entrance and exit will usually effect the removal of clot and pulped brain, the latter often oozing out in quantity from the exit wound. It is usually not possible to close the dura, but the scalp is carefully sutured.

One will frequently be called upon to decide what should be done with a wound of the scalp with an underlying linear fracture. The decision for craniotomy should be based purely on the probable extent of intracranial damage as evidenced by neurological signs, and of these by no means the least important is the degree to which consciousness is affected. If in these circumstances operation is undertaken, the vexed question of whether the dura should be opened does not arise. But on other occasions this question may be debatable. One has, however, always believed that the fate of many head wounds rests on the integrity of the dura, and that this membrane should not be incised unless there are clear indications of local or diffuse cerebral compression.

The cases with entrance wound only, and therefore with retained foreign body, are controversial. The X-ray examination will show the position of the missile, often deep in the brain. After the usual wound toilet, how much is to be done in an attempt to remove this foreign body? One feels that, despite X-ray examinations in two planes, the actual location of these metallic fragments at operation will demand skill and experience which the general surgeon does not possess. The fragments are usually small (any large fragment is apt to cause such damage that recovery is unlikely) and as a search for them is likely to be unsuccessful and even harmful, they are better left undisturbed.

Compound Fractures.

There is little that one can contribute to the ways and means of treating fractures. A brief survey of the methods which one has used may, however, be given with special reference to compound fractures of the femur and humerus.

Fractures of the Femur.—The problem resolves itself into (*a*) the treatment of the wound, and (*b*) the immobilization of the fracture. The writer has no doubt that it is the primary treatment of the wound upon which the fate of the limb and often the life of the patient depend. Often the size of the wounds of entrance and exit is no criterion of the extent of damage within the limb.

One remembers a man with a through-and-through wound of the mid-thigh, neither entrance nor exit being very large. The limb was taken out of the Thomas splint and the serious state of affairs became apparent, for the fracture site was felt to be sickeningly flabby. The wounds were widely opened, when it was found that about five inches of femur were badly comminuted and nearly every muscle of the thigh had been divided. A mid-thigh amputation was performed. Evidence was subsequently produced that the missile which was the probable cause of such widespread destruction was a shell from the cannon of a Messerschmitt.

All wounds of the thigh in the presence of a fracture of the femur should be widely opened. The skin wound is excised and the *fascia lata* is split upwards and downwards for about five inches. It is then divided at the centre of the split in a backward and forward direction. Retractors of the Farabeuf type with deep blades are now inserted and the edges of the lacerated muscle are widely retracted. The actual depths of the wound and fracture site can now be inspected. Pieces of clothing will often be found; completely detached portions of bone are picked out, all lacerated muscle is excised, and hæmostasis can be obtained. The wound is thoroughly irrigated with hot saline solution and then swabbed with acriflavine and dried. "M & B 693" powder on a Volkmann's spoon is evenly distributed over the surface of the cavity, into which a large blob of "Vaseline" is introduced. The exit wound is similarly treated. Drain tubes or rubber dam are not used in any circumstances. The wounds are covered with a flat gauze dressing and the limb is dealt with in a way which will be described. The method described above should make immediate appeal on general principles. Every general hospital contains patients with gunshot wounds of the femur who have discharging sinuses, who are pale and cachectic, and who are dying. One is convinced that this state of affairs owes its origin not only to the inefficient wound excision but to the inadequate drainage provided at the first operation.

By trial and error, a method by which the fracture can be immobilized has been produced. The surgical team in Cyrenaica had deficiencies in particular equipment and the treatment of a fractured femur was a compromise. The team possessed no Kirschner outfit and the application of an adequate spica plaster as a routine was limited by the conditions under which the team was working and by the amount of plaster available. One had to be content with applying fixed extension with strapping—at the best only temporarily efficient—to the limb slung in a straight Thomas splint. In addition, attempts were made to immobilize the limb in the splint by figure-of-eight plaster bandages or by wide flannel bandages over cotton wool packing. (In passing, let it be said that the maintenance of extension by clove hitch, however applied, is liable to so many complications that it should be discarded.) Reports from casualty clearing stations and base hospitals were unfavourable, for in general the fractures carried badly. During the Syrian campaign the surgical members of the casualty clearing station endeavoured not only to ensure that adequate immobilization was obtained, but to learn from the patients themselves after evacuation what degree of discomfort they suffered during their journey to the base.

However, it is hardly fair to compare the Western Desert and Syria, for in these two campaigns the evacuation was carried out under very different conditions. In the former a large number of the men with fractured femurs had to be evacuated over an extremely bad road for long distances and naturally they suffered. In the latter, those travelling to base by ambulance enjoyed a good road, while some went by ambulance train.

While minor modifications were employed at times, the following description may be taken as the method most often used in the casualty clearing station.

The surgical toilet of the wound having been completed, a Kirschner wire is inserted through the crest of the tibia just below the tubercle, and the stirrup is attached in the usual way. A Thomas splint (preferably the British pattern with well padded, well shaped ring) is bent to an angle of about 30° at the knee. While the limb is being slung in the splint the end of the latter is held by an orderly so that its distal half is horizontal. The suspension bar is now fixed on the stretcher so that its position coincides approximately with the junction of the middle and lower thirds of the

Thomas splint. When this has been done, it will be found that the suspension bar lies just proximal to the foot. The splint is then slung from the suspension bar by a flannel bandage from each of its side bars. Lateral movement is prevented by a tightly stretched bandage from each side bar to each upright of the suspension bar. If the splint is suspended from the stretcher bar at its end, the sides of the splint are not rigid enough to prevent "bouncing" of the limb during evacuation. A piece of strong twine is then passed through the centre hole in the Kirschner stirrup. This twine cannot be passed to the end of the splint and tied because the foot lies in the line of direct pull. A Sinclair's reversible stirrup is strapped onto the side bars of the Thomas splint in such a position that the cross-member of the stirrup lies just distal to the sole of the foot. Each end of the twine then passes outside the vertical and over the horizontal member of the Sinclair stirrup. The ends of the twine rejoin at the notch in the end of the Thomas splint. The Kirschner stirrup is then pulled with one hand while the slack in the twine is taken up with the other. During this process of extending the limb the Sinclair's stirrup should be steadied by an orderly. The necessary extension is produced and fixed by tying the twine around the end of the splint. Patients with fractured femur treated in this way were contacted personally at base hospitals and invariably they stated that they had travelled without discomfort. This was confirmed to some extent by the surgeons receiving them; the surgeons were able to say that all arrived in good condition and none in great discomfort.

Fractures of the Humerus.—The traditional method of treating fractures of the humerus at certain sites in abduction cannot always be employed in war. In field medical units modification is necessary because a man with his arm in abduction cannot be placed in an ambulance. Moreover, the treatment of these, or indeed of any fracture, in a casualty clearing station differs from that in a hospital in one important particular. The ultimate aim which the hospital surgeon will endeavour to achieve is union in good position. The aim of the casualty clearing station surgeon is to obtain immobilization without particular reference to anatomical perfection. At times a man with a fractured humerus will travel quite comfortably with the limb encased in Cramer wire in full extension and bound to the side. As a rule, more elaborate methods are necessary adequately to immobilize the fracture. The wound is treated in the usual way. A plaster slab is then prepared of such length that it will extend from the vertebral border of the scapula to the metacarpal heads. The upper end of this slab is about twelve inches wide (so that the shoulder and scapular regions can be covered) and gradually diminishes in width towards the hand. The limb is placed with the arm abducted about 30°, with the forearm flexed to a right angle, and with the hand in the mid-prone position. An orderly holds the hand and at the same time extends the arm by pulling in the crook of the elbow. The slab is then applied up to the base of the neck, over shoulder and scapular regions and along the postero-external border of the limb. It is rapidly fixed by a plaster bandage running its whole length. Reinforcing slabs are made for pectoral and scapulo-humeral areas and for the region of the elbow, and these are incorporated in the main plaster. The whole is then fixed to the trunk by a few six-inch plaster bandages, the position of slight abduction still being maintained. During these proceedings the orderly continues to pull in the crook of the elbow. No attempt is made to apply a formal plaster spica; neither are struts of plaster or Cramer wire inserted for support between plaster and trunk. The cast is, perforce, applied to an unconscious patient in the semi-recumbent position. When the patient recovers consciousness and sits up, it will be found that the plaster does not appear to fit very well at its upper end. This does not detract from the function for which it is designed, for immobilization is secured and moderate reduction of the fracture can be maintained.

BASE HOSPITAL MANAGEMENT OF SOFT TISSUE INJURIES.[1]

By B. K. RANK,
Major, Australian Army Medical Corps.

(From the Facio-Maxillary and Plastic Surgery Unit of an Australian General Hospital, Abroad.)

THIS paper is not written to advocate a method of treatment, but that it may stimulate a more active interest in the earliest possible effective healing of war wounds. The basis and details of a routine of management of certain soft tissue injuries as carried out by the plastic surgery unit at an Australian general hospital are given. There is no originality of method, but an attempt has been made to apply at a base hospital under active service conditions methods known to be effective under more ideal conditions.

The early treatment of war injuries must be influenced by consideration of evacuation and other arrangements of mobile war conditions. It follows that under more suitable and fixed base hospital conditions a modification in plan of management must often be considered. It may be required to discontinue methods absolutely indicated for earlier stages of treatment if by doing so earlier or better results can be obtained.

This has special application to the management of the very large number of soft tissue injuries which occur.[2] With this class of wound, particularly the smaller wounds, many battle casualties are still potential fighting men and it is essential that maximum functional results are obtained in minimum time. To this end, full advantage must be taken of some modern observations and advances in control of wound infection. The repercussions of this in obtaining more rapid healing of wounds, either spontaneously or by secondary surgical procedures, should be noted. This applies to all wounds irrespective of their size. It is evident in the Middle East, as in other theatres of war, that much delayed healing and prolonged hospitalization may result from continuation of a relatively passive interest in the later treatment of soft tissue injuries, especially of the more trivial.

CONTINUED PASSIVE MANAGEMENT OF SOFT TISSUE WOUNDS AND ITS DANGERS.

The larger wounds have usually been treated in forward areas by surgical *débridement* and closed plasters. The enormous advantages of immediate treatment on these lines are well known. It is established not only by its effectiveness but by its suitability to mobile war conditions. All writers stress the value of the "closed plaster method" in minimizing or preventing sepsis and its complications.[1][2] Elimination of much of the risk of secondary infection by infrequent exposure and dressing is important, though this risk is not excluded.[3]

Regarding the later phases of wound healing under continuation of the closed plaster regime (that is, after the dangers of sepsis are largely offset by

[1] Accepted for publication on November 1, 1941.

[2] Soft tissue injuries associated with bony damage are not primarily considered in this paper, as bone injury must usually take priority in the indications of treatment. With many compound fractures, however, where the soft tissue damage is out of proportion to the bony damage, there comes a time when the more rapid healing of the soft tissue wound may be considered. This may be not only compatible with, but advantageous to, the continued treatment of the bone injury along ideal lines.

well-established local defence processes), and regarding the remote results of healing under these conditions, there is need for review.

In order to indicate the advantage of the closed method as an aid to healing, it has generally been compared with the "open method" of frequent "antiseptic" dressings as carried out before modern knowledge of the effect of chemotherapy and of its special advantages to surgical methods was available.[4]

The time taken for the healing of a wound under a continuous closed plaster varies enormously, not only with the size and site of the wound and with the degree and type of infection, but also with the actual amount of tissue loss. For large wounds it is important that a distinction be made between the apparent and the real size of the wound, the latter depending on the amount of tissue lost (by injury, excision and sepsis in varying amount). A lacerating wound with disruption of the fascia and prolapse of muscle bellies may expose a big raw surface with but relatively little skin loss. The fact that this common type of wound may "draw in" and heal surprisingly quickly in relation to its apparent size leads to a misconception that all large wounds heal in optimum time and manner under plaster. This is not so. Wounds with large skin losses and varying degrees of infection do not do well under continuous passive treatment. The cicatrization of slow healing by secondary intention with the formation of scars poor in texture and often unstable may cause much consequent malfunction.

Prolonged immobilization in itself may be conducive to similar results, which are poor repayment for a long stay in hospital. Higgs notes,[5] as a chief disadvantage of the closed treatment of wounds in plaster, the poor quality of skin which regenerates under the plaster and the thick indurated, keloidal type of scar. Such results might be avoided if assisted healing by secondary suture or skin grafting was considered after arrival of the casualty at a base hospital and the wounds were actively prepared for such a procedure. It does seem that a closed plaster can outlive its enormous early advantages. (An adherent coagulum about a burn can be considered in the same light. Its persistence can unnecessarily delay early preparation for healing and function, especially if, as is so common, it is associated with sepsis.)

The smaller wounds have usually been excised and may or may not be enclosed in plaster. They are usually allowed to heal spontaneously, being treated by dressings varying in frequency and protean in variety. The common sequel to this is secondary infection of the wound, and it is noticeable that many of these wounds take a time to heal which is out of all proportion to their size. After many weeks they may present an appearance characteristically indolent, and may have become "chronic wounds".

"Chronic wounds" cause an undue amount of hospitalization in the Middle East. They represent failure, retarding or arrest of the normal process of secondary intention healing. Their characteristic (see Figure 1) is an indurated, raised and keloidal edge stopping abruptly at the granulating area, and there is no sign of the thin and actively growing blue edge of the healthy wound. Varying amounts of low-grade cellulitis may be evident in the region of the wound, and the granulating area may be anything from atrophic to hypertrophic. An undue amount of deep fibrosis causes fixture to surrounding tissues and undue functional disability. When ultimately healed, the scars are unsatisfactory and pass through a long phase of instability or repeated breakdown.

Causes of Delayed Healing and Chronic Wounds.

Bone sepsis, tendon sloughing and especially retained foreign bodies are well-known local causes of delayed healing of war wounds, always to be

considered when persistent sepsis is evident. Undue local mobility of regions over bony points or inadequate rest for the part may retard healing. For smaller wounds, especially during the later stages of healing, the possibility of self-interference must not be forgotten. A poor general condition, such as might be accounted for by blood loss, by varying degrees of septic absorption, or by dietary insufficiencies and prolonged fatigue, must be corrected by appropriate means. But, even in the absence of any of the above factors, there remains a large group of soft tissue injuries which make "chronic wounds". It is now evident that the chief cause of most of this delayed healing of wounds is secondary streptococcal infection so common among war injuries. The report of the War Wounds Committee of the Medical Research Council[6] indicates the widespread hospital infection of wounds. The committee found it not unusual that 70% of the wounds in a ward (in Britain) were infected with *Streptococcus pyogenes*. In the Middle East the same state of affairs exists, probably to a greater degree. Of 172 wounds examined at this base hospital after the patients' admission, 63% carried hæmolytic streptococcal infections. Of ten chronic wounds investigated in which there was no other obvious cause, all were infected with the hæmolytic streptococcus. Minor skin infections are rife: bites and scratches readily become infected with the streptococcus. Keogh has noted that 98% of "desert sores" are streptococcal infections, and the healing time taken by some of these is notorious. There is every chance for the early infection of war wounds even before the possibilities of hospital cross-infection arise.

Significance of Streptococcal Infection.

Though the streptococcus as a cause of spreading tissue infection and gross general infection is so well known, the harm it does as a surface infection is often not fully realized, especially as it may so often persist on what are thought to look like "healthy wounds". On a wound surface, quite apart from being a potential cause of the spreading and general infections, its capacity to inhibit epithelial proliferation, so necessary to secondary intention healing, is now apparent. The essential feature of all this delayed healing is the inactivity of the growing epithelial edge. The appearance of a granulating area means little, as it is influenced by so many factors (pressure, type of infection *et cetera*). The common expression, "healthy granulations", may be misleading and is often meaningless. It is the condition of the wound edge that best indicates the health or otherwise of a wound. Hypertrophic granulations, often called "healthy", are commonly associated with gross hæmolytic streptococcal infections. When epithelial activity is retarded, the normal relations of healing processes are upset: granulations are persistently making fibrosis, but peripheral epithelialization is not occurring. As time goes on, other factors of diminished local circulation by fibrosis are induced and make the problem of the "chronic wound" a very real one. At this stage control of local infection in itself may be inadequate to produce satisfactory healing and more radical treatment is often indicated for wounds which have reached this stage (excision *et cetera*).

No matter what the theoretical cause, the practical consideration is the special histolytic property of the streptococcus. Even on normal skin its digestive properties are clinically notable (witness the edge of a spreading streptococcal ulcer). Not only is spontaneous healing so inhibited, but secondary surgical procedures are rendered ineffective and perhaps dangerous. This was fully recognized by Carrel[7] when he specified that no secondary suture should be undertaken in the presence of any streptococcal infection of the wound. More important is what we now know of skin grafting, so often indicated. In the past it has been impossible to produce uniformly good

results by secondary grafting of granulated wounds. The writer has shown[8] how in practised hands and with all modern refinements of technique the results of secondary skin grafting in no way compared with the uniformly good results of primary grafting on surgical wounds. Sepsis was the cause of failure (of 144 grafts to granulating wounds in only 41% could the "take" be classified as good—that is, over 75% "take"). These figures should be compared with those set out later in this paper.

FIGURE I. Photograph of a "chronic wound" taken sixteen weeks after injury.

Figures I and II are photographs of "chronic wounds" taken respectively sixteen weeks and twelve weeks after the injuries. The primary treatment in both cases had been wound excision (in the second case closed plaster had been used). Both failed to heal under varying régimes of dressings. Both in their chronic state gave positive streptococcus cultures.

The wound depicted in Figure I was caused by shrapnel on January 21, 1941. It was situated in the anterior aspect of the upper part of the thigh. Excision was carried out at a casualty clearing station. Plaster was not applied. On February 26, 1941, the wound was described in the clinical notes as "a clean granulating wound, but healing is very slow".

On May 2, 1941, the patient was still in hospital and the wound was unhealed. The patient had been two months in bed. It was on this day that the photograph reproduced in Figure I was taken. After sulphanilamide preparation the wound was treated by wide excision, and a thick razor graft was applied on July 1, 1941. The patient was discharged from hospital with the wound soundly healed and with no functional disability.

The wound depicted in Figure II was a gunshot wound of the upper part of the calf. It was excised at a casualty clearing station and the limb was enclosed in plaster. The plaster was removed after four weeks and the wound was then treated by dressings.

FIGURE II. Photograph of a "chronic wound" taken twelve weeks after injury.

On May 20, 1941, the day on which the photograph reproduced in Figure II was taken, gross functional disability was present. After sulphanilamide preparation this wound was treated by wide excision and the application of a thick razor graft. After a period at a convalescent depot the patient was seen again; the graft had established its stability and the function was much improved. The patient was returned to the base with a "B" class classification.

In the light of what we have since learned, most of these failures were probably due to uncontrolled surface streptococcal infections. The early days of chemotherapy proved disappointing in this direction, as it was found that

use of specific drugs by mouth did not improve results of grafting on granulating wounds; it apparently had little effect on the surface infection.

Control of Surface Streptococcal Infection.

Colebrook, working with the Gillies School of Plastic Surgeons, has shown[9] that by a correct use of sulphanilamide locally on granulating wounds these can be cleared of streptococcal infection in a few days. The most convincing proof of this is that skin grafting done by the same surgeons, using the same principles of technique—that is, the local use of sulphanilamide—can now show results hitherto unknown in the history of skin grafting on open wounds. Mowlem draws attention to the uniformly good results which can now be obtained by secondary grafting of granulating wounds,[10] and the results obtained here conform with this.

ACTIVE MANAGEMENT OF SOFT TISSUE INJURIES.

The value of ability to eliminate surface streptococcal infections in war surgery must be fully recognized (the same may apply to other infections, but these have not been the bugbear to wound treatment). A broader view need be taken of the whole problem of prevention of secondary infection of wounds. Every wound with a streptococcal infection must be treated not only for the sake of its own healing capacity, but for the sake of all other wounds in a ward possibly exposed to the risks of cross-infection. It would pay admirably for all the principles of hospital routine to be reviewed in the light of the Report of the Medical Research Council. By active prevention and elimination of streptococcal infection not only will normal healing be unembarrassed, but it will be possible to undertake active surgical procedures for wounds of size and these with uniformly good results.

In what follows, various points in a routine of active management adopted by the plastic unit at an Australian general hospital are indicated. Most of the wounds treated in this department are candidates for skin grafting by virtue of a raw surface area or are "chronic wounds" which have failed to heal under varying periods of treatment at the base. These wounds include burns which at this stage of management can generally be considered on identical lines. All are treated actively as candidates for grafting, though other surgical procedures are sometimes carried out, and adequate spontaneous healing may dispense with the need for surgery. These principles could be well applied to all soft tissue wounds at a base hospital.

Wound Examination.

Wound examination includes bacteriological examination, carried out mainly to indicate the presence or otherwise of streptococcal infection. This is only a minor bacteriological procedure, but it is an essential part of the preliminary scrutiny of a wound for possible causes of delayed healing. A few relative graft failures have been due to retained foreign bodies, unsuspected or missed. All wounds are now submitted to X-ray examination if there is any possibility whatever that fragments have been retained.

General Condition.

In almost all cases in which a raw area more than six inches by six inches has been present a blood transfusion has been indicated by varying degrees of clinical anæmia and debility. Hæmoglobin estimation is done as a routine procedure, and a reading of under 65% is taken as an absolute indication for transfusion.

With the aid of the Australian Red Cross, diet is varied and supplemented as much as possible with due regard to vitamin content.

Preparation Routine.

Preparation routine is carried out for all wounds, irrespective of whether they are candidates for spontaneous healing, secondary repair or skin grafting. It is impossible to make fast rules of when a closed plaster should be abandoned. This is done at the earliest time it is considered safe so to do, and depends on associated injuries, general condition, site and type of wound. Most wounds have been of about a month's duration and the preparation routine has been commenced on the patient's admission to hospital. Burns[1] are seen at a stage when septic toxæmia is the only real threat to life and when the earliest possible healing and return to function are the prime consideration. For this reason a coagulum has also outlived its prime use—often life-saving—and is removed, as later indicated.

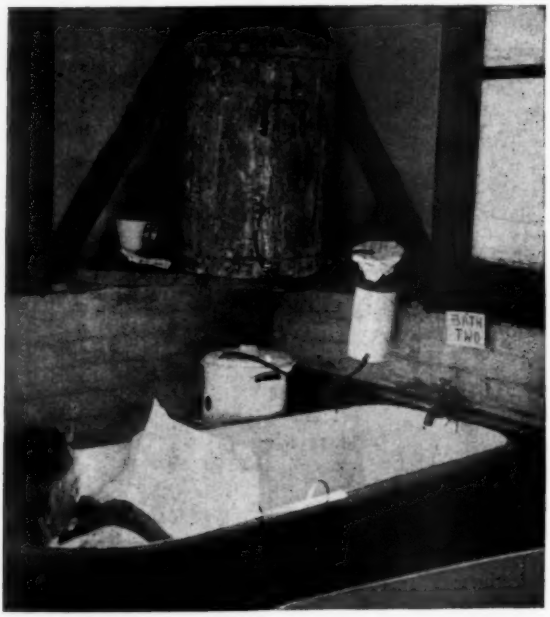


FIGURE III. Showing patient in an improvised hypertonic saline solution bath.

The preparation has as its objects: (i) gross cleaning of the wound by removal of sloughs, débris, adherent tan *et cetera*; (ii) bacteriological preparation, aiming at the elimination of streptococcal infection and reduction of other surface infection to a degree compatible with skin grafting; (iii) mechanical preparation of the granulating area to reduce this to a regular firm base; (iv) functional preparation of the part by massage, movement or exercise, so that nothing is lost by unnecessary prolongation of immobilization and stiffness.

Saline Baths.—The value of saline baths in assisting and preparing for early epithelialization of burnt areas has been demonstrated by Blair and Brown in America and by Macindoe in Britain.[11] These principles are applied for all wounds. Baths, in the care of an orderly, are given once a day.

[1] *Burns.*—The treatment of burns is still one of the major unsolved problems of war surgery. At "base hospital" stage the treatment of sepsis, usually present, and preparation for early healing and function are the chief consideration. To this end the saline bath routine is used and tan is removed. This gives the same satisfactory results as obtained elsewhere. Under the conditions of warfare in the Middle East, coagulation as the advance method of treatment cannot be replaced for any case in which there is even the remotest threat to life; there is no satisfactory alternative. One must plead against any malapplication of tannic acid or other coagulating agents (that is, before adequate cleansing is carried out), and for due consideration of important functional areas, especially with severe burns. Hands, faces and flexure lines should not be coagulated, but covered with a "Vaseline" type of dressing.

The choice of optimum stage and method of evacuation for patients with burns under Middle East conditions is a chief difficulty. Patients with severe burns travel worse than those with any type of war injury, especially if the injury is associated with an infected tan. Aeroplane evacuation for selected patients is a solution. As soon as the danger of secondary shock is passed, they could be sent back to a base hospital adequately prepared for a saline bath routine. For early and good functional results from severe burns this seems the best method of treatment yet available.

The baths themselves are of an improvised nature (Figure III). Under local climatic conditions no special thermostatic control is required and drying causes no difficulty. Arm baths have been made which allow full elbow movement and footbaths are used; otherwise all wounds and burns have full-size body baths. Hypertonic saline solution (2%) is used. Brine is made periodically in a tank from standard measures to a 20% solution; this is filtered into a second tank. Standard amounts of this filtered solution are added to a bath with hot and cold water to marked levels, to make a 2% saline bath. The temperature, checked by a thermometer, is 90°; anything hotter is not tolerated for any long period. This temperature is well maintained, but it may be necessary to add more hot water for a long period bath. First baths are made only half strength and last about half an hour, but the time is rapidly extended up to three or four hours if the patient is comfortable. It is considered that there is no such thing as "too long" in the bath. Baths are fitted with trays which enable the patient to read, smoke or take his meals if required.

A high temperature in itself does not contraindicate bath treatment; the orderly stays constantly with all sick patients. The previous day's dressing is soaked off—they float off with little handling—and opportunity

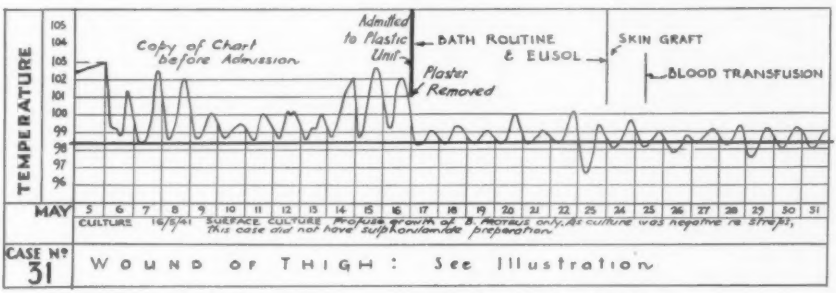

TEMPERATURE
105
104
103
102
101
100
99
98
97
96
Copy of Chart before Admission
Admitted to Plastic Unit
BATH ROUTINE & EUSOL
SKIN GRAFT
BLOOD TRANSFUSION
Plaster Removed
MAY
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 25 24 25 26 27 28 29 30 31
CULTURE 16/5/41 SURFACE CULTURE Profuse growth of B. PROTEUS only. As culture was negative re STREPT, this case did not have sulphonlamide preparation
CASE Nº 31
WOUND OF THIGH : See Illustration

FIGURE IV. Showing temperature chart in Case XXXI.

is taken to remove with forceps as much slough and débris as possible. Adherent tan comes off burns easily when soaked. The masseuse carries out or encourages such function as is compatible with the lesion.

The advantages of this régime may be enumerated: (i) The lavage effect on extensive wounds diminishes toxic absorption and it is found that temperature rapidly subsides (see Figure IV). The hypertonic solution favours wound drainage.[12] (ii) The saline solution has a specific effect in stimulating epithelial proliferation. (iii) Hypertrophic sloppy granulations, so characteristic under plaster, are reduced to a firm regular condition suited to grafting. (iv) It permits maximum early function, most valuable for small joints. (v) The bath routine eliminates the horrors of painful and traumatizing dressings. It is admirably suited to a hot climate where the adequate and kindly nursing of an extensive burn may be otherwise nigh impossible. The cleanliness of the bed is notable, as is the absence of that malodour associated with an infected tan.

Certain difficulties must be recognized. A good and keen team is required, for though a team is encouraged by results, this régime does mean extra work. The dangers of cross-infection from exposure and bath contamination must be recognized and checked by a thorough aseptic routine. Baths are cleaned after each patient with a household cleaner and a one in 20 solution of "Lysol". This is done with a long handled brush and after ten minutes the bath is rinsed out.

Dressings.—Dressings are done once a day, after the bath. Due recognition of the risks of secondary infection is made. During all wound inspections and dressings sterilized forceps are used and masks are worn by all watching or participating. (Details conform as far as possible to the suggestions of the Medical Research Council report.[6])

1. If streptococci are present on culture, sulphanilamide is used locally by the method as advised by Colebrook.[9] The wounds are cleared of all possible débris about their surface and edge; sloughs are actively cut away. For large wounds and burns two pairs of hands are required to avoid undue exposure and drying of the surface. Before the surface dries it is covered with powdered sulphanilamide from a blower which gives easy access and distribution to wounds of all types and in all places (Figures V, VI and VII). Enough is used to give the "hoar-frost" appearance.

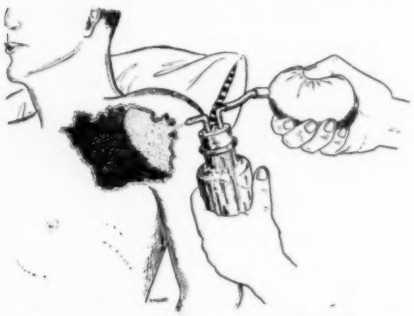


FIGURE V. Showing the insufflation of powdered sulphanilamide onto the wound before it dries; enough is applied to give the wound a "hoar-frost" appearance.

FIGURE VI. Showing *tulle gras* being placed over the raw surface.

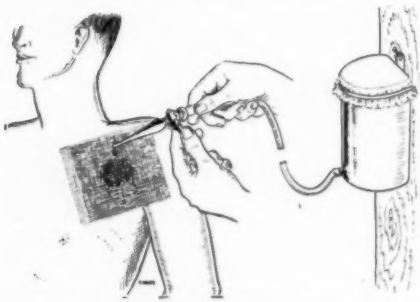


FIGURE VII. Showing saline solution packs being placed outside the *tulle gras*. These are kept damp throughout the day by rewetting. When not in use, the nozzles on the wall can tubing, which need not be touched, are covered with sterile bags.

The wounds are then covered with *tulle gras*,[1] an indispensable dressing for this work, as it combines the advantages of being non-adherent and permeable to surface discharge. Moist saline solution packs are then applied, and these are held by gauze bandages or light jaconet wraps. The dressing is kept moist all day by being rewet (two or three times daily) without being undone. Rewetting is done from a wall can of normal saline solution fitted with a tap nozzle or a small dressing can be moistened from an undine. Intelligent patients are allowed to do this themselves. Dressings left to dry, as they quickly do in this climate, cause much discomfort and trauma to the wound from chafing and during their removal. Colebrook emphasizes the importance of retention of moisture and of the application of the sulphanilamide powder to the wound

[1] *Tulle gras* is made in the wards. Two millimetre mesh coarse cotton curtain netting is cut to the size of available tins, about six inches by four inches. On each piece is spread, with a spatula, the mixture: "Vaseline", 99 parts, and balsam of Peru, 1 part. The net is then placed in the tins, alternating with layers of grease-proof paper cut to the same size. Sterilization is carried out in the autoclave with the linen.

before it dries. Wounds are seen which have had long periods of local sulphanilamide treatment without streptococcal control. This is explained by incorrect application of the powder as a dry dressing or application on an insufficiently clean and moist surface. (Sulphanilamide resistant types of streptococci are fortunately uncommon in wounds.)

2. If streptococci are not present on incubation, sulphanilamide is not used. Eusol packs[1] are used outside the *tulle gras* and these are kept moist from a wall can of eusol. This is alternated with saline solution for one day after two days on eusol. By this routine, surface discharge is reduced to a degree compatible with effective secondary grafting. (It was probably these cases which gave some good results before the use of sulphanilamide.)

The only other agent used is acetic acid (a 2% solution) or malt vinegar, for obvious *Streptococcus pyocyaneus* infections which are cleared in about two days; very little of this has been noted.

Apart from being kept moist, dressings are undisturbed until in the bath next day, except for removal of outer bandages. *Crêpe* bandages, as firm as can be comfortable, are applied in the evening after the dressings are last damped. Pressure is important in the adequate preparation of a granulating wound.

Sunlight, a very effective and cheap bactericidal agent, is used for all smaller wounds. These are exposed to the sun after the bath, under the supervision of the masseuse. The wounds and their edges are partly protected by a single layer of fine gauze soaked with paraffin; the exposure is graduated. These wounds require moistening again before sulphanilamide is used.

Duration of Preparation Routine.

The clinical appearance tells when the wound is adequately clean for grafting. The health of the wound is assessed by the activity of its skin edge—a wound clean enough to own an active edge is clean enough to take new skin. Granulations are rendered firm by the saline solution and pressure routine in about seven days. Wounds which are not found to clean up in this manner should be actively reviewed regarding foreign bodies and pocketing. Here one notices the value of a thorough primary excision. Except on the face and hands, it seems that nothing is gained by conservation of an extra half inch of jagged edge, possibly undermined. The clinical condition of the wound and its size, type and position decide whether spontaneous healing will suffice or whether it is necessary to carry out some form of secondary suture or repair or to skin graft; when in doubt, the last mentioned should be chosen. Swabs have been taken as a routine procedure from wounds on the day of an operation and it is found that the result almost always conforms with the clinical appearance. Such reports as "*Staphylococcus aureus* only" and "No pathogens isolated" are the rule. Before any secondary surgical procedure is undertaken, it is the practice to give sulphanilamide by mouth—seven tablets twice a day for three days before operation and five tablets twice a day after operation for large areas or what have been gross infections; patients with other wounds receive five tablets twice a day for three days after operation only. No sulphanilamide is given on the day of operation.

Skin Grafting.

Only two main types of graft are applicable to granulating wounds, namely, pinch grafts or razor grafts.

Razor Grafts.—Razor grafts of various thickness can be used with uniformly good results on granulating wounds correctly prepared. They give

[1] Eusol is incompatible with sulphanilamide.

dramatic healing and maintain good stability, especially if cut fairly thick. There is usually very little left to heal by secondary intention, and areas healing in this way make less stable scar. A disadvantage is the necessity for a general anæsthetic. Sufficient healthy skin[1] must also be available. The thicker the graft is cut, the less its subsequent contraction, and it has been the practice to cut the grafts so thick that the donor area will be allowed to heal spontaneously. (Thick razor grafts are also called thick Thiersch grafts, split skin grafts, intermediate grafts or dermo-epidermal grafts.) Figures VIII, IX and X illustrate a case in which these grafts were used.

FIGURE VIII. Case XXXI. Showing condition of wound on May 22, 1941.

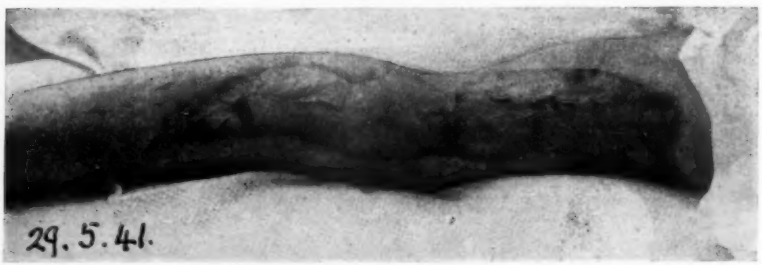


FIGURE IX. Case XXXI. Showing condition of wound on May 29, 1941.

FIGURE X. Case XXXI. Showing condition of wound on July 18, 1941.

[1] This disadvantage may be partly solved by: (*a*) The dermatone (E. Padgett, *Surgery, Gynecology and Obstetrics*, Volume lxix, page 779), an instrument for cutting skin of even and set thickness. It has the advantage that skin can be cut from trunk regions not suitable to a razor knife; but it is an expensive piece of apparatus, its use depends on the efficacy of an adhesive, and it requires almost as much practice to use efficiently as does a razor knife. (*b*) Homogeneous grafts which may also be of use in selected cases. These have been used in two cases with good "take", but one of the grafts suffered a complete delayed autolysis commencing after one month. The real value of these grafts must still be regarded as undetermined.

FIGURE XI. Case XCVIII. Showing burns from petrol before bath treatment and the use of sulphanilamide.

The patient in this case (Case XXXI) was wounded on April 10, 1941, by a bomb explosion. Primary treatment consisted of the excision of the wound and the application of plaster. The plaster was changed several times until the patient was admitted to the plastic unit on May 16, 1941, for skin grafting. His temperature chart is reproduced in Figure IV. The plaster was removed on the day of his admission and a profuse collection of pus was found to be present. From this pus *Bacillus proteus* only was grown in a culture medium. The routine of saline baths and eusol preparation was commenced. The condition of the wound on May 22, 1941, is shown in Figure VIII.

The operation was undertaken on May 24, 1941, and thick razor grafts were applied. The first dressing was done in May 29 and there was "100% take". The condition of the wound on that day is shown in Figure IX.

On June 5, 1941, epithelialization was complete; a few small areas had not been covered by skin. On June 12 the patient started exercises, and on June 29 he started weight bearing.

The condition of the wound on July 18, 1941, is shown in Figure X. On July 29 the patient was discharged to a hospital ship. The graft was sound and the patient was walking well, considering the muscle loss. Though he was "D class", the functional and early result of such a gross lesion is noteworthy.

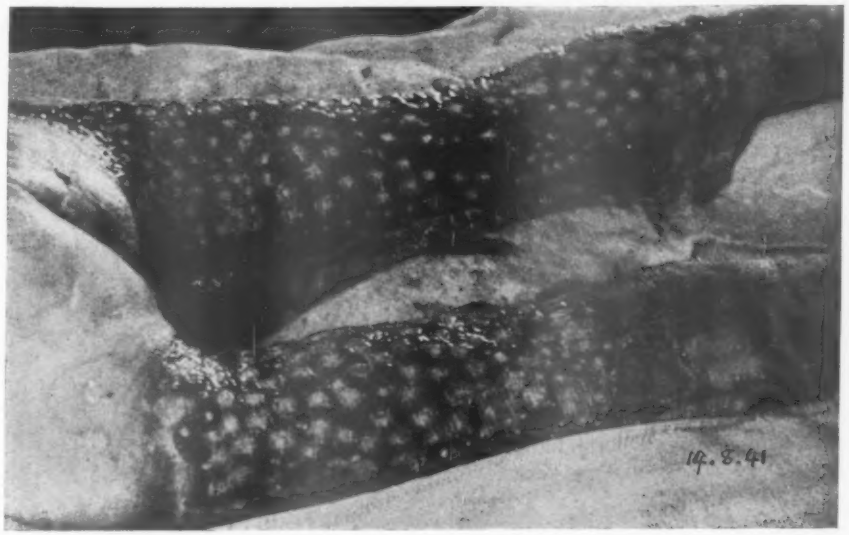


FIGURE XII. Case XCVIII. Showing pinch grafts which have taken.

Pinch Grafts.—Pinch grafts can be applied to any wound. Their disadvantage is the extra time taken for completion of epithelialization from the extra edges introduced and stability of the secondary intention scarring between the pinches takes longer to be established. They are used: (*a*) for small areas when a general anæsthetic is unwarranted, (*b*) when the patient's condition may contraindicate general anæsthesia, (*c*) for very large areas, as those associated with some burns, when insufficient other skin is easily available. Unlike razor grafts, they do not cover a whole surface and are therefore compatible with a greater amount of surface discharge, for obvious mechanical reasons. Thus they are of special value for soft tissue wounds associated with a compound fracture when discharge is perpetuated from a bone infection or sinus. Figures XI and XII illustrate the use of pinch grafts.

The patient (Case XCVIII) was burned with petrol on May 5, 1941. He was treated at first by tannic acid and later had various dressings with the aid of morphine. He was admitted to the plastic unit on July 14, 1941. His general condition was

extremely bad. His hæmoglobin value was only 37% (Sahli). He had a pressure sore on the buttocks, his morale was completely broken, and he presented a very difficult nursing problem.

On July 16, 1941, a bacteriological examination was made and a profuse growth of hæmolytic streptococci was obtained from the surface of the wound. The state of the lesion is shown in Figure XI. Saline bath routine and sulphanilamide preparation were commenced. He received a blood transfusion. On July 25 no hæmolytic streptococci could be grown from the surface of the lesion.

On July 26, 1941, operation was performed. Pinch grafts were applied to all the raw areas on the dorsal aspect, except the left calf and the left popliteal region, which were covered with homogeneous razor grafts. On July 31 the first dressing was done. There was a complete "take" of the pinch and the homogeneous razor grafts.

On August 2, 1941, routine bath treatment was commenced again and another blood transfusion was given. On August 8 neither *Bacillus pyocyaneus* nor *Streptococcus hæmolyticus* could be grown from surface secretion. On August 9 operation was again performed and pinch grafts were applied to all the remaining raw areas on the front of the legs. Figure XII shows the lesions as they were on August 14. By September 9 epithelialization was complete, the patient was rapidly gaining in weight and was having exercises in bed.

When other grafting procedures such as full thickness skin, flaps or pedicles might ultimately or even soon be indicated, pinch or razor grafts should still be applied to granulating wounds as a palliative procedure. The results of these secondary methods on surgically clean areas produced by palliative grafting are far superior to those following any programme of mass tissue transfer to a raw granulating area.

Technique.—Chief technical details of razor grafting as carried out are illustrated in Figures XIII to XVIII. It is generally the practice to remove thick or long-standing granulation tissue (potential fibrosis) when present. The raw areas are covered with sulphanilamide powder before application of razor grafts and on top of all pinch grafts.

After-Care.—Grafts on open wounds are left with their pressure dressings undisturbed for five days when the first dressing is done. This is earlier than has been usually practised and the dressing must be very carefully done. By doing the first dressing early, discharge about overlapping areas and patches or about any areas of failure can be cleared, and grafts which would be relative failures may be saved. If allowed to accumulate, pus may infiltrate beneath otherwise viable skin. Pressure is then reapplied for two or three days and thence dressings are done every day. The bath routine is carried on if there is any extent of raw area, and always with pinch grafts. The local application of sulphanilamide is continued for wounds which previously carried streptococcal infection, as it is found that this sometimes recurs.

When healing is completed, the areas are massaged lightly each day with lanoline, and full functional exercises are carried out in bed. For leg areas weight bearing is not allowed for one or two weeks after healing, depending on the area, and then only with the support of a firm bandage. If there is any suspicion of instability, a further period of non-weight bearing is instituted. This phase is most important. For areas of failure, regrafting must be considered after appropriate preparation. Pinch grafts are usually applied among persisting islands of a razor graft which has been a relative failure, for, if left, these areas are sometimes very slow in healing.

Results Obtained.—In the past four months fifty skin grafts have been done on open wounds prepared by the above routine. Twenty-five of these were razor grafts, and the twenty-five results may be summarized as follows:

Complete take (100%)	11 cases (44%)	80% good results
Good take (over 75%)	9 cases (36%)	
Fair take (under 75%)	3 cases (12%)	
Failures (0%)	2 cases (8%)	

The figure 80%, classed as good results, is almost double the figure given earlier in this paper for this type of graft on open wounds before the days of local sulphanilamide preparation.

FIGURE XIII. Razor grafting. Cutting the graft. Grafts are cut by the free-hand method as shown with the use of a razor knife (Blair), which must be correctly sharpened. Practice and a sharp knife are required. The postero-lateral aspect of the thigh—off the line of the femur—is the easiest site for a good size graft. The under edges of board and knife are smeared with "Vaseline".

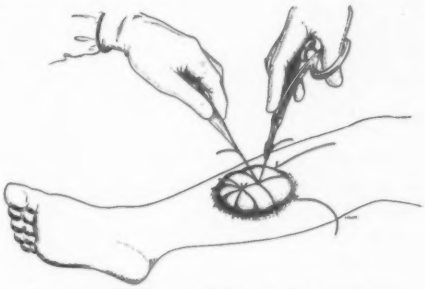


FIGURE XVI. Razor grafting. Long sutures overtied over a carefully moulded pack of paraffin and flavine wool (ordinary dressing wool wrung out in equal parts of liquid paraffin and flavine one in 1,000, made as an emulsion). The wool is put on layer by layer in plaques and pressed down with gauze. The mould is built up to a contour, suited to an even pressure from an outer bandage. The mould gives fixation, but not much pressure.

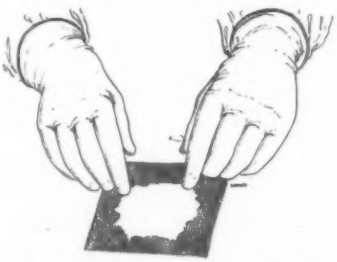


FIGURE XIV. Razor grafting. Spreading the graft on *tulle gras*, on which it is subsequently handled with ease and convenience.

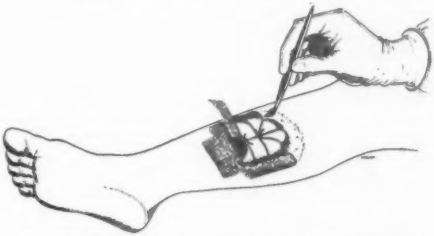


FIGURE XVII. Razor grafting. Folded gauze is packed about the edges of the mould if and as required by the contour of the part. "Mastisol" is used freely about the area to fix the gauze and minimize any shearing from the outer bandage.

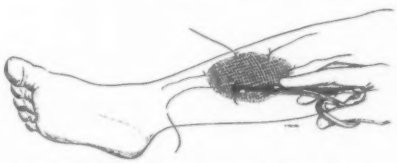


FIGURE XV. Razor grafting. Anchoring sutures to the wound edge through skin and *tulle gras*. Some stitches are left long. Note that stitching is done from the inside outwards.

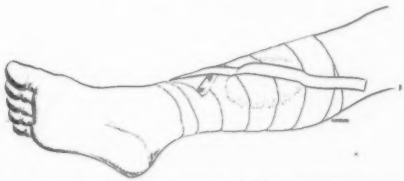


FIGURE XVIII. Razor grafting. Pressure is applied usually by a *crêpe* bandage, which is fixed by the "Mastisol". An outer piece of strapping prevents any displacement of the bandage layers. It is the rule to cover all *crêpe* bandages with light gauze bandages to keep them clean from without, as the *crêpe* bandages are washed and sterilized and used over and over again.

An analysis of the failures and relative failures is significant. In one case (over 50% take) there was sepsis from the region of an unsuspected foreign body. In two cases (under 50% take), both complicated by uncontrolled streptococcal infection (as shown by cultures), there was pocketing

about the edges in one and multiple foreign bodies in the other. In two cases failure was complete; sepsis was responsible in both and multiple small foreign bodies were present in both.

Among 25 cases in which pinch grafts were used, only four could be classified as having poor results or failures. Six secondary repairs or sutures have been done with one failure from sepsis, and several wounds have been allowed spontaneous healing.

CONCLUSION.

The small figures mean little in themselves, but experience indicates that such routine of management gives better functional results and certainly saves much time as compared with a continued passive management of wounds, whether plaster is used or not.

Such results can be attained only by due recognition of the risks of secondary streptococcal infection of wounds and of the importance of its prevention and treatment. One of the common causes of delayed healing of wounds can be eliminated and surgically assisted healing can be instituted for wounds of any size with good result. Healing time need be no function of wound size. The problem of the "chronic wound" can be minimized, and many of the problems confronting a plastic surgeon, following a slow secondary intention healing, with the curse of fibrosis, can be prevented.

ACKNOWLEDGEMENTS.

I wish to acknowledge the help and encouragement which I have received from Major E. V. Keogh (pathologist at an Australian general hospital), Colonel K. B. Fraser (commanding officer of an Australian general hospital) and Colonel W. A. Hailes (consulting surgeon, Australian Imperial Force). I thank the Director of Medical Services (Australian Imperial Force) and Director-General of Medical Services for permission to submit this paper for publication.

REFERENCES.

(1) J. Trueta: "The Treatment of War Fractures by the Closed Method", *Proceedings of the Royal Society of Medicine*, Volume xxxiii, November, 1939, page 65.

(2) J. Trueta and J. M. Barnes: "The Rationale of Complete Immobilization in Treatment of Infected Wounds", *The British Medical Journal*, July 13, 1940, page 46.

(3) E. Spooner: "Discussion on the Closed Plaster Treatment of Wounds", *Proceedings of the Royal Society of Medicine*, Volume xxxiv, 1940-1941, page 4.

(4) J. d'Harcourt, A. Folch and A. Oriol: "The Closed Plaster Method of Treatment", *The British Medical Journal*, April 20, 1940, page 652.

(5) S. L. Higgs: "Discussion on the Closed Plaster Treatment of Wounds", *Proceedings of the Royal Society of Medicine*, Volume xxxiv, 1940-1941, page 4.

(6) A. A. Miles *et alii*: "Hospital Infection of War Wounds" (An Interim Report of the War Wounds Committee of the Medical Research Council), *The British Medical Journal*, December 21 and 28, 1940, pages 855 and 895.

(7) A. Carrel and Deheely: "*Le traitement des plaies infectées*", translation by H. Child, 1917.

(8) B. K. Rank: "Use of the Thiersch Skin Graft", *The British Medical Journal*, May 25, 1940, page 846.

(9) L. Colebrook and A. Francis: "Elimination of Streptococci from Superficial Wounds by Sulphanilamide Powder", *The Lancet*, March 1, 1941, page 271.

(10) R. Mowlem: *The Lancet*, March 1, 1941, page 278.

(11) A. H. Macindoe: "Treatment of Burns", *Proceedings of the Royal Society of Medicine*, Volume xxxiv, 1940-1941, page 1.

(12) Almroth Wright: "Memorandum on the Employment of Bandages for the Irrigation of Wound Surfaces with Therapeutic Solutions, and the Draining of Wounds", *The Lancet*, October 16, 1915, page 879.

PRELIMINARY REPORT ON INTERNAL DERANGEMENTS OF THE KNEE JOINT TREATED AT AN AUSTRALIAN GENERAL HOSPITAL, AUSTRALIAN IMPERIAL FORCE ABROAD, TO MAY 31, 1941.[1]

By R. V. GRAHAM,
Major, Australian Army Medical Corps.

AN Australian general hospital commenced work on February 13, 1940. The period chosen for review in this report extends from that date to May 31, 1941, and may be conveniently divided into three periods: (*a*) From February 13, 1940, to May 31, 1940, during which no operating theatre was available which could be considered safe for any but emergency operations. (*b*) From June 1, 1940, to December 31, 1940, during which a modern operating theatre was in use, but the patients referred to in this report were nursed in a hospital marquee. (*c*) From January 1, 1941, to May 31, 1941, during which all patients operated on were housed in well-ventilated huts with paved floors.

The 128 operations on the knee joint referred to in this report were performed in the period from June 1, 1940, to May 31, 1941, and represent all patients selected for operation out of 486 patients referred to this hospital with a tentative diagnosis of internal derangement of the knee joint.

The area in which this hospital is located is one where it had previously been considered unsafe to operate during the summer months. During dry weather *"Khamsins"* (winds) frequently lasted for three days, and the unpaved roads, with almost complete absence of vegetation, were responsible for frequent troublesome dust storms.

Ventilation of the hospital marquees in which the patients were nursed was incompatible with the exclusion of dust, and the limbs of the men were almost continually bathed in perspiration while confined to bed.

For some months the floors of the marquees consisted of tarpaulins spread on the ground, which to a certain extent mitigated the dust nuisance, although the constant passage of feet from outside made it impossible to attain any reasonable degree of ward cleanliness. During the later months of 1940 concrete floors laid in the marquees partially solved this problem.

During 1940 running water was available in only a few marquees, and means of sterilizing it were very primitive. During this period troops in this area were undergoing training over ground much of which was intersected by deep wide drains and *"wadis"*, or was composed of loose sand. Football was a favourite recreation, and appeared to have influence on the incidence of these cases. Slit trenches had been dug in many places for protection from air-raids, and were blamed for some of the injuries, while motor transport was also incriminated. In only one instance was it alleged that routine physical training was the causal agent.

Various problems arose in relation to the diagnosis and treatment of these patients, but the greatest problems occurred in the after-treatment, and these were largely inherent in the environment and conditions of service.

Such patients find little difficulty in gradually completing convalescence while carrying out part or all of their civil occupation, but on active service only two alternatives are usually available in the disposal of the convalescent

[1] Accepted for publication on November 3, 1941.

patient until he is fit to return to his unit and resume the arduous duties of the soldier: (*a*) to detain him in hospital, (*b*) to discharge him to convalescent depot until he is fit to return to his unit.

Efforts to solve these problems have resulted in certain modifications in previous routine, which will be referred to later in this report. Many of the soldiers operated on have not only resumed duty, but have been through several arduous though relatively short campaigns, each of which was of such a nature that the function of the knee joint was submitted to the severest possible test. It is felt that sufficient time has elapsed to warrant a preliminary report on these cases, although it is recognized that subsequent observations may necessitate some modifications in the ultimate results recorded.

HISTORY.

Soldiers referred to this hospital for treatment of disabilities of the knee joint may be classified into:

A. Those with internal derangement of the knee joint of such a degree that arthrotomy was indicated.

B. Those with minor derangements of a mechanical nature, for example, sprains of the medial collateral ligament associated with gross trauma, or with minor degrees of trauma due to faulty foot posture.

C. Those with "quadriceps insufficiency" resulting from previous operative interference.

D. Battle casualties producing penetrating wounds of the knee joint.

E. Fractures, simple or compound, involving one or other of the component parts of the knee joint.

F. Subacute infections.

G. A group in which the symptoms were due to lesions of the hip joint.

This report refers to Group A only; those in other groups will be described in a subsequent report. Most of the patients falling in Group A gave a history of some injury which had been sustained subsequent to enlistment. Such injuries are referred to as "recent" and the term "old" is reserved for any injury described as occurring prior to enlistment.

Ninety-four described a recent injury to the knee joint, but fifteen of this number admitted old injuries in addition. Seventeen who claimed no recent injury ascribed their disability to an old injury. Of the 111 patients who described some definite injury, 56 stated that the violence was of a twisting nature. The remainder were not able to state clearly what type of trauma had occurred.

Forty-two men gave a history of locking, but only two could give a clear description of subsequent "unlocking". Twenty-one of the forty-two stated that there had been locking on more than one occasion.

The cause of derangement could be ascertained from 77, and two stated that they had never suffered any injury, although subsequent arthrotomy disclosed a lacerated meniscus (Table I).

SYMPTOMS.

Symptoms described served in the majority of cases only to give a general idea of disability and showed the usual variation in individuals.

Insecurity or "giving way" of the knee during marching, in running or in times of stress, such as climbing over rough ground or over sandhills, was most common.

Aching pains after long marches and various degrees of effusion were described, but were rarely present at the time of examination.

Locking was accepted as a symptom in 42 cases only, as in these cases the patients gave an unequivocal account of the phenomena usually associated

TABLE I.

Summary of Causes of Internal Derangements of Knee.

Cause.	Number of Cases.
History indefinite	49
Football	33
Cricket	2
Wrestling	2
Ditches and slit trenches	14
Alighting from moving cars	5
Fall from a height	11
Marching	4
Rising from squatting posture	3
Physical training	3
No history of trauma	2

with this event, and also a description of events subsequent to the locking which was consistent.

Great care was necessary in accepting such descriptions, as the close association of men on active service tends to lead to unconscious imitation in describing some limitation of movement as locking. Only two men gave an unequivocal description of "unlocking" after locking.

SIGNS.

Limitation of Movement.—Two soldiers reported for examination while the knee was locked. Varying degrees of limitation of flexion were observed in seven cases: one lacerated lateral meniscus and six medial.

Limitation of extension was observed in 23 cases: 18 of lacerated medial meniscus, two of lacerated lateral meniscus, and three in which both menisci were lacerated.

Limitation of flexion and extension were observed in 10 cases: eight of lacerated medial meniscus, one case of lacerated medial and lateral menisci, and one case of cyst of the lateral meniscus.

Undue Mobility.—Varying degrees of undue antero-posterior mobility were observed in 20 cases of lacerated menisci: five patients described an old injury only, seven described a recent injury following an old injury, and eight described a recent injury only. In two instances of old injury there was undue lateral mobility.

Local Tenderness.—Local tenderness was discovered at the time of examination in 55 cases; its incidence is summarized in Tables II, III and IV.

Effusion.—Effusion of varying degrees was present at the time of examination in 41 cases; its incidence is summarized in Tables V and VI.

In two cases aspiration of the knee joint before operation disclosed a hæmarthrosis; and in 10 cases without previous aspiration it was found at operation.

TABLE II.

Incidence of Local Tenderness in Internal Derangements of Knee.

Condition.	Number of Cases.
Lacerated menisci	50
Hypermobile menisci	3
Congenital abnormality of menisci	1
Congenital dislocation of patella	1

TABLE III.

Relation of Tenderness to Time of Injury.

Type of Injury.	Number of Cases.
Old injury	9
Recent injury following old	6
Recent injury only	40

TABLE IV.

Sites of Local Tenderness.

Site.	Number of Cases.
Subpatellar	1
Anterior end of medial meniscus	44
Anterior end of lateral meniscus	2
Femoral attachment of medial collateral ligament	4
Tibial attachment of medial collateral ligament	2
Posterior aspect of knee joint	2

TABLE V.

Relation of Effusion to Time of Injury.

Type of Injury.	Type of Effusion.	
	Transient. (Number of Cases.)	Persistent. (Number of Cases.)
Old injury	2	8
Recent injury following old ..	1	3
Recent injury only	11	16

TABLE VI.

Relation of Effusion to Lesion.

Lesion.	Number of Cases.
Lacerated meniscus	39
Hypermobile meniscus	1
Congenital dislocation of patella	1

Manipulation.—A characteristic "click" on passive manipulation of the knee from flexion to extension with the leg abducted and laterally rotated was obtained in 19 instances. In 17 of these the patient gave a history of recent injury; two gave a history of old injury. In all of these the meniscus was found to be lacerated at subsequent operation.

Swelling.—Swelling localized to the anterior or medial portion of the medial meniscus was present in six cases, in each of which it was proved to be due to the lacerated portion of the meniscus.

Swelling over the postero-lateral portion of the lateral meniscus was present in all cases of cyst of this meniscus, but in some instances appeared to be solid, owing to the tension of the aponeurosis.

Radiological Signs.—In no instance was the radiograph of any value in diagnosis of lesions of the medial meniscus. In two instances in which

osteochondritis dissicans with partially separated loose body was discovered at operation, the radiograph failed to give any indication of this condition, even on careful scrutiny after operation. No instance of "loss of joint space" in the radiograph was found. In two cysts of the lateral meniscus, the radiograph showed flattening of the lateral condyle of the tibia with a small spur of bone on the lateral edge of the articular surface, which has been described as characteristic of this condition.

DIAGNOSIS.

Review of the signs and symptoms presented by this series of cases emphasizes some of the difficulties inherent in the attempt to arrive at an accurate diagnosis prior to arthrotomy.

The first step in attempting to arrive at a diagnosis should consist in the taking and recording of a careful history, particular inquiry being made into the exact nature of the violence, position of the limb with regard to the body at the time of injury, subsequent movements immediately after the injury, time of onset and nature of disability following injury, duration of disability and subsequent history of the patient. In every instance careful inquiry should be made for any history of disability in the involved joint prior to injury, and for any evidence of involvement of other joints in the body. Care should be exercised to avoid any leading questions, as they may easily suggest to a patient that limitation of movement due to pain should be described as locking.

It rarely happens that a critical and trained observer witnesses the "locking" and almost as rarely does the patient give an unequivocal account of "locking and unlocking".

When the history of this event may be accepted, and is accompanied by localized tenderness over the anterior end of the medial meniscus, particularly with slight limitation of extension, it warrants a confident diagnosis of internal derangement.

Manipulation may provide additional evidence, but its failure to produce evidence is of no value as a diagnostic sign.

Radiographic evidence of arthritis or loose body is sometimes present in authenticated cases of lacerated meniscus. In most instances there are no positive signs when the patient reports for examination. One is often compelled to rely upon indirect evidence in deciding to recommend arthrotomy.

In these cases the accuracy of the history and its interpretation must assist in the correlation of any signs discovered on examination.

DIFFERENTIAL DIAGNOSIS.

The 486 cases diagnosed as internal derangement of the knee joint included, in addition to the 128 discussed in this report, sprains of medial collateral ligament, contusions of patella, hyperæmia of synovial membrane adjacent to patella, recurrent dislocations of the patella, chronic and subacute infective arthritis, bipartite patella, old lesions of cruciate ligaments, bilateral epiphyscolysis, unilateral epiphyscolysis, "traumatic synovitis".

The terms "traumatic synovitis" and "traumatic arthritis" are responsible for many delays in correct diagnosis and treatment of internal derangements of the knee. Careful inquiry into the details of the injury and the time relation to it of the subsequent signs and symptoms will indicate in most cases a mechanical and not an inflammatory cause for this condition.

Most cases so diagnosed have been shown at operation to be cases of lacerated meniscus, the "synovitis" or "arthritis" being a sequela rather than a cause of the disability.

TREATMENT.

One eminent authority has said that the greatest difficulty in treatment of these conditions is diagnosis. This is probably true when the diagnosis is made against the background of the modern metropolitan hospital. The position was reversed in this Australian general hospital, as more problems were associated with treatment and after-treatment than with diagnosis.

It was decided to operate in these cases as soon as possible after a diagnosis of internal derangement was arrived at with a reasonable degree of certainty.

The first difficulties arose from scarcity of the linen and spirit necessary for the usual three preparations of the limb, but it was decided not to relax these precautions; this aspect of the work was carried out so meticulously by the nursing staff that no instance of post-operative sepsis occurred.

Most of these operations were performed under spinal anæsthesia, and hæmostasis during operation was secured by tourniquet. For this purpose a strip of rubber about three feet long by one and a half inches wide, cut from a discarded motor tube, was found very useful. The tourniquet was sterilized with the instruments and applied to the thigh after the limb was draped. With the knee flexed over the end of the table an incision one and a half inches long was made three-quarters of an inch medial to the medial border of the patella, extending from the edge of the articular surface of the femur in the line of the fibres of the joint capsule. Side towels were fixed to the skin edges with Michel clips, which were used again with subsequent cases. Four clips only were used for this purpose. A headlight was used for illuminating the joint during the subsequent steps of the operation.

An effort was made to dissect out as much of the meniscus as possible, the separation of its posterior attachment being facilitated by traction with a strong vulsellum and dissection with oblique strokes of a fine tenotome. At this stage the joint was examined as fully as possible by the aid of the headlight, and other pathological conditions were dealt with.

The synovial membrane was closed with a continuous suture of "000" catgut, a few bleeding points in the subcapsular tissues were tied, and the capsule was united with a continuous suture of "00" catgut. In the earlier cases the skin was also united with fine catgut and a dressing of one in 2,000 acriflavine was applied and secured by a flannel bandage over a large pad.

Many of these wounds appeared to heal by first intention, but about the eighth day a dull blush appeared around the wound edges, the catgut absorbed and portion of the wound broke down into an indolent ulcer which sometimes took two or three weeks to heal. At this time the catgut in use was supplied in sealed tubes. It was also observed during these hot months that the limbs encased in bandage and dressing were bathed in perspiration during the day. In order to eliminate these two possible sources of infection, the routine was modified by using interrupted sutures of fine silk for the skin, and dispensing with the pad and bandage. A small roll of gauze—one "throwaway"—moistened with a solution of acriflavine was used as an anchored dressing, secured by three sutures of silk or silkworm gut. Since this modification was introduced the mild inflammatory reaction in the wounds about the eighth day has completely disappeared.

In a personal communication the Consulting Surgeon to the Middle East Forces has informed the writer that he arrived at the same solution of this problem in India with equally satisfactory results.

No pad or bandage of any kind has been used for dressing in these cases since August, 1940.

The influence of an anchored dressing on post-operative hæmarthrosis has been debated, but as it is impossible to secure all bleeding points inside the

knee joint, a post-operative hæmarthrosis is inevitable after such operations. It seems logical, therefore, to take such steps in after-treatment as will hasten absorption of the effused blood, and prevent formation of adhesions, rather than to attempt to prevent effusion by measures which *per se* prevent attainment of these ends.

AFTER-TREATMENT.

The after-treatment aims at the promotion of earliest possible active use of the quadriceps muscle. Pain associated with the idea of an operation on the knee leads to inhibition of cortical control of the quadriceps, and unless this is overcome within the first few days, it is liable to dominate the picture for weeks or months.

The sutures and anchored dressing are removed seventy-two hours after operation, and no dressing of any kind is used thereafter, the wound being painted with *Tinctura Benzoinæ Composita* once daily to provide a waterproof covering.

The four interrupted silk sutures uniting the skin edges are not removed for fourteen days, as there is a tendency for repair of wounds to be slightly delayed in this area.

For twenty-four hours after operation the patient is kept with head low, until he has recovered from the spinal anæsthetic.

During this period he is made to contract the quadriceps without lifting the heel off the bed; when any difficulty exists, contraction of the quadriceps on the side not operated on soon builds up a mental picture of the required movement, which is then easily imitated on the side on which operation has been performed.

At the end of twenty-four hours the heel of the limb that has been operated on is supported on a pillow, the patient is then made to contract the quadriceps, and, while keeping it contracted, to lift the heel one inch off the pillow. Provided this movement is performed as a continuous movement without sudden jerking, very little pain results.

It is sometimes necessary to encourage a timorous patient by assisting elevation of the heel with a little passive support, but even where pain is complained of, efforts are not relaxed until this active elevation of the heel is achieved.

Once the patient realizes that he can actively elevate the heel after actively contracting the quadriceps, he willingly cooperates in this exercise. Having achieved this active contraction of quadriceps and elevation of the heel from pillow, he is instructed to perform this movement every half-hour during his waking hours, and the sister or some of his fellow patients supervise it during the first day.

At the end of forty-eight hours the patient can elevate the whole limb, with quadriceps contracted, off the bed, and he now sits up, lifts the limb without any aid across the bed, and sits with the leg projecting over the side of the bed, allowing the knee to flex slowly with the aid of gravity.

If he is apprehensive, he is liable to contract the quadriceps suddenly and so to cause pain. In such cases the observer's finger placed beneath the heel supplies just enough resistance to promote confidence, and the patient will then actively contract the hamstrings, thus reflexly relaxing the quadriceps and flexing the knee. Very rarely does one fail to attain flexion to 90° at the first attempt.

While in this position, the patient now contracts the quadriceps till the knee joint is fully extended, and without any extraneous aid lifts the limb back into its former position on the bed.

This exercise is repeated every hour during the day, and he rapidly regains full control of the knee.

At the end of seventy-two hours he stands out of bed, is instructed to contract the quadriceps fully in order to immobilize the limb, and then walks round the bed, especial care being taken to see that the limb is not permitted to bear weight unless the quadriceps is firmly contracted.

As the leg is carried forward in walking, it is usually necessary to instruct the patient to flex the knee and lift the foot well off the ground, as the concentration on immobilizing the limb, while weight bearing, tends to make him continue to hold it rigidly as he carries it forward for the next step.

As soon as he has learned to walk round the bed, he is allowed to walk about the ward, but no man is allowed to walk with a limp, and no sticks or crutches are permitted. If a man tends to walk with a limp, it can easily be prevented by insistence on adequate contraction of the quadriceps while the limb is bearing weight, and by making him take equally long paces with each foot. The few men who persist in walking with a limp after seventy-two hours are put back to bed and given more reeducation of the quadriceps.

This aspect of after-treatment is greatly facilitated by grouping all such patients in one portion of the ward, so that the patient may learn from those who have been operated on a few days before him. It then becomes the responsibility of convalescent patients to instruct new ones in quadriceps exercises before operation, and also to assist in instructing them in correct walking afterwards, although due acknowledgement must be made to the painstaking supervision of the sister in charge of the ward.

During the latter part of 1940 two patients had large effusions into the knee joint after operation, and it was deemed necessary to aspirate the joint in order to permit more active movement. In each instance about 60 cubic centimetres of blood-stained fluid were withdrawn, but there was no appreciable difference between the time required for these men to attain full function and that required when no aspiration was done.

Effusion in the knee joint after operation, in the absence of inflammatory signs, is not regarded as an indication for rest, but rather as an indication for graded muscular activity and for increased use of the knee joint in walking.

In this series of cases, effusions, when present, responded to activity in less time than they formerly responded to rest. Many men showed a complete absence of effusion after three weeks. Some effusions persisted, with gradual absorption, for two months, and a few for three months, but observation during after-treatment showed no undue mobility of the knee joint which could be attributed to the effusion, and progressive absorption occurred during recovery of full muscular activity.

In this connexion an opportunity was taken to see the work of Mandl at the Hadassah Hospital, Jerusalem. He maintains that post-operative effusion is prevented by: (*a*) removal of lacerated portion of meniscus only; (*b*) use of "Novocain" and adrenaline for anæsthesia; (*c*) the cutting of a window in the synovial membrane of the suprapatellar pouch and the pushing of a pair of forceps into the connective tissue beneath the quadriceps; (*d*) closure of the synovial membrane and capsule with silk sutures which emerge through the skin and are removed on the eighth to the tenth day.

The only patient in this series in whose treatment this technique was used had an indurated area beneath the quadriceps corresponding in outline with the suprapatellar bursa for two and a half months. It was felt that no advantage over methods described was to be derived by the adoption of this technique.

From three days after operation until the fourteenth day these patients assist in ward duties, and have regular walking exercises at intervals during the day.

During 1940 they were then transferred to a convalescent depot, but frequently returned to hospital with insufficiency of the quadriceps and persistent effusions in the knee. Facilities for reeducation and supervision being greater at hospital, it was then decided to retain these men in hospital for a long period, so that they could be discharged direct to depot battalion for redrafting to units.

As demands on hospital accommodation gradually increased, it became necessary to curtail the period of retention in hospital, but the need for frequent supervision still existed.

This problem was solved by the erection of tents in the men's lines at the hospital, to which these patients were transferred as soon as the sutures were removed and they no longer needed nursing attention. They were given the privileges of soldiers, but were also given light duties, such as assisting mess orderlies, assisting in postal duties, acting as runners to various departments and wards. They were in addition required to attend at the massage department twice a day for graduated quadriceps resistance exercises.

A parade was held before the commencement of duties on three mornings per week, in order to check the reaction of each man's knee to resistance exercises. When considered fit, they were discharged direct to depot battalion, and thence drafted to units.

With few exceptions, the men appreciate the opportunity of doing some useful work, and also enjoy the associated privileges. Results of this experiment have been highly satisfactory.

PATHOLOGICAL CONDITIONS DISCOVERED AT OPERATION.

The pathological conditions discovered at operation are summarized in Table VII. When multiple conditions were found at operation they are recorded under each individual condition.

TABLE VII.

Pathological Conditions at Operation.

Condition.	Medial Meniscus.	Lateral Meniscus.	Both Menisci.	Remarks.
Anterior laceration ..	24	5	—	
Posterior lacerations— Single .. .. Double	44 5	8 —	6 —	Torn fragment displaced in 11.
Complete lacerations (bucket-handle) ..	21	2	1	Lateral fragment in intercondyloid fossa in 17.
Hypermobile ..	8	—	—	
Congenital abnormalities	2	1	—	Meniscus represented by fibrocartilaginous cord sessile, attached to anterior capsule.
Loose bodies	9	—	—	Associated with lacerated meniscus.
Cysts	—	6	—	
Discoid meniscus ..	2	—	—	Also included unlacerated.
Hypertrophied synovial fringes	14	—	—	Associated with lacerated menisci.
Osteochondritis dissecans	4	—	—	Two cases not demonstrated by radiograph.
Arthritis	5	—	—	Associated with lacerations of menisci.

COMPLICATIONS AND SEQUELÆ.

In this series of 128 arthrotomies there has been no post-operative sepsis. There has been no sign of inflammatory reaction in the wound, with the exception of the cases occurring in the early months of the second period, in which a late low-grade inflammation in the deep tissues led to absorption of skin sutures and delayed healing of the wound, and three cases early in 1941, in which there was for a few days some superficial redness which in no way delayed union of the wound.

Post-operative effusion has been dealt with as previously described under after-treatment, and did not assume the role of a complication.

Arthritis of a low grade was present at operation in five cases. In two of these the patients were subsequently found "B" class by a medical board. The other three patients were considered to be suffering from conditions caused by old injuries to the meniscus and resumed active service. Two of these three have since been classed "A" by the medical board. One has since reported for consultation for another complaint; he states that he went through the Libyan campaign without any trouble from his knee, and now shows no evidence of arthritis. One resumed active service with his unit, and unfortunately died of wounds in Syria. The other cannot be traced, but there are no medical records of subsequent disability.

Some men have shown a tendency for effusion to return on the first resumption of route marches with depot battalion, but this has not persisted, provided they pay adequate attention to the maintenance of quadriceps function. On the contrary, some men admitted to this hospital for persistent effusion after removal of menisci followed by prolonged rest, have responded to graduated resistance exercises with progressive disappearance of effusion as the quadriceps improved.

RESULTS.

Under the routine established at this hospital for treatment after transfer to the after-treatment ward, these patients are not discharged from hospital until considered fit for light duty with the depot battalion. The criterion adopted is that there shall be no effusion after exercise for at least a week prior to discharge, no pain, and full function of the quadriceps with a stable knee joint. The average stay in hospital was forty-two and a half days, and

TABLE VIII.

Summary of Patients Remaining in Hospital More than Seventy-five Days.

Days in Hospital.	Age.	Initial.	Condition.	Reason for Delay.
85	25	C.	Lacerated medial meniscus.	Persistent effusion.
76	37	K.	Lacerated medial meniscus.	Three weeks "sprained medial collateral ligament" before operation.
92	42	P.	Lacerated medial meniscus.	Three weeks medical ward "functional dyspepsia".
81	25	P.	Lacerated medial meniscus.	Persistent effusion.
93	32	R.	Lacerated medial meniscus.	Three weeks investigation. ? Charcot. No reaction to Kline test.
82	40	L.	Lacerated medial meniscus.	One month sprain medial collateral ligament before knee locked.
86	34	T.	Lacerated medial meniscus.	"Traumatic arthritis."

the average time after which men ceased to report effusion after route marches was seventy-five days. Consequently light duty is recommended until seventy-five days after operation. Since the adoption of this routine no men have been referred for recurrent disability.

In this series seven men remained in hospital more than seventy-five days, as shown in Table VIII.

At the instance of the Consulting Surgeon, Australian Imperial Force, a census was taken of the 128 cases quoted in this report, and their medical records were examined; the findings of medical boards were included. Table IX gives a summary of these results.

DISCUSSION OF TABLE IX.

Of those boarded "B", four were found Class "B" for conditions not associated with the operation: "otosclerosis", "average only (48)", "recurrent dislocation of patella", and "functional dyspepsia".

Of those boarded "C", four were declared "A" subsequent to May 31, 1941. If the 15 still in hospital are deducted from 101 not boarded, the remainder (86) may be presumed to be fit for active service, as their medical records show that they have not been treated in hospital nor have they been referred to medical boards.

TABLE IX.

Summary of Medical Records of 128 Cases Quoted in this Report.

Group.	Number.
Not boarded at May 31, 1941—presumed on active service	101
Still in hospital at May 31, 1941 (category not yet determined)	15
Boarded—found "A" class	2
Boarded—found "B" class	15
Boarded—found "C" class	9
Boarded—found "D" class	1
Total	128

The two found Class "A" by medical boards and the four Class "C" who have subsequently been elevated to Class "A" added to the 86, give 92 who are fit for active service.

Of the 15 still in hospital it is reasonable to argue that at least a similar proportion (that is, 92/128 or ¾) will be fit for active service.

Thus at least 86 + 2 + 4 + 12 or 104 of 128 patients operated on for internal derangement of the knee joint are fit for active service, and 15 are fit for service other than with field formations, while one has been found unfit for service.

SUMMARY.

1. Records of 128 patients operated on for internal derangement of knee joint at an Australian general hospital have been analysed.

2. Of this number at least 104 are fit for active service.

3. A further 15 are fit for service other than with field formations.

4. One patient has been found by medical board unfit for service.

5. The average time between operation and discharge to light duty in depot battalion was forty-two and a half days.

6. The time allowed for resumption of full duty was seventy-five days or two and a half months after operation, and the classifications given under Table VIII were based on this routine.

7. Football was the most frequent cause of internal derangement.

8. Organized physical training was the least frequent cause alleged in this series.

9. Many of these patients presented no positive signs on examination.

10. A careful history correlated with physical signs is the first step essential for arriving at a diagnosis.

11. Absence of physical signs is of no negative diagnostic value.

12. Apart from "locking", the most frequently observed signs of diagnostic value were local tenderness, persistent effusion, limitation of extension and the results of manipulation.

13. In this series there was no post-operative intraarticular sepsis.

14. In a few cases some low-grade inflammatory reaction occurred in the subcutaneous tissues about eight days after operation; this ceased after pads and bandages were discarded in favour of a small anchored dressing and silk was substituted for catgut for cutaneous suture.

15. Early active use of the quadriceps muscle in walking is the most important point in after-treatment.

16. Splints, crutches and walking sticks were forbidden.

17. Persistent effusion was regarded as an indication for, and not a contraindication of, active function of the quadriceps.

18. Grouping post-operative cases in the ward and early transfer to the after-treatment ward in the hospital, with early assumption of light duties, have been found of great value in the promotion of early recovery of full function.

ANKYLOSIS OF THE JAW: CARTILAGE GRAFT RESTORATION OF THE JOINT: A NEW OPERATION.[1]

By H. P. PICKERILL,
Wellington.

ÆTIOLOGY AND GENERAL REMARKS.

THE majority of cases of ankylosis of the temporo-mandibular joint seem to originate in infancy or early childhood, but do not become manifest for some years after the originating cause has subsided. The two chief causes are trauma and infection.

In regard to trauma it has to be remembered that the neck of the condyle of the mandible is peculiarly liable to injury from falls upon the chin, and especially when the fall is a "helpless" fall such as occurs with small children or unconscious adults. When an adult who is conscious falls forward the chin is automatically protected by his bending the head forwards and by raising the arms. An unconscious fall of an adult results in a fracture of the neck with a rotation forwards of the head in the glenoid fossa, owing to the contraction of those fibres of the external pterygoid muscle attached to it. This may, or may not, give rise to a subsequent ankylosis, but it is not this kind of thing which occurs in childhood because the angle of the jaw is much more obtuse, and the condyle is more in line with the point of the chin; consequently, when a very young child falls on the chin, a telescopic form of fracture occurs. The neck of the bone is driven up into the head and the joint surfaces are damaged considerably. It is this form of fracture which gives rise subsequently to ankylosis. A history of injury can often be obtained on careful inquiry, such as a fall out of a cot, off a bed or down some steps, followed by earache or a swelling in front of the ear. Parents, however, rarely associate this pain or swelling with the fall, or with possible damage to the joint. It is of value to search for such a history since it may give a clue to the side on which the ankylosis is.

Direct trauma in civilian life rarely gives rise to ankylosis. In wartime, however, with high explosive fragments flying in all directions, it is not uncommon to find that the whole joint has been comminuted, or a fragment of shell lodged in it. Again the possibility of subsequent fixation of the joint seems to be rarely noted, probably because the patient does not complain either of pain or inability to move the joint. Fixation comes on so slowly that it is only after considerable disability in opening the mouth has arisen that the patient complains. The same sequence is observed in children, though in them the process is more gradual, extending over five to ten years before the child is brought for examination and then closure and fixation are sometimes absolute.

It is to me extraordinary that parents should not become extremely alarmed by the closure of the child's jaw, but so long as the child can absorb nourishment, even though he cannot masticate, they do not seem to be greatly troubled. Here I would like to interpose two observations.

In the first place, I have seen several cases in boys and adolescents in which no mastication has been possible for years and yet general growth,

[1] Accepted for publication on August 14, 1941.

development and mentality have been normal, and the teeth, although unused and uncleaned on their masticating and inner surfaces, have not been unduly subject to caries; neither have I ever been told of any discomfort or pain after food. Where, then, is all our teaching as to the necessity of mastication and dental hygiene?

In the second place, in regard to the infrequency with which any throat complications occur in such patients, I always ask parents: "Has a fish bone ever stuck in his throat?", or "Has he ever had a quinsy or diphtheria?" "No", they say, "not as far as we know." At my next question—"But what would you have done if any of these things had happened?"—they become for the first time alarmed and realize the seriousness of the condition.

FIGURE I. Typical marsupial facies of long-standing ankylosis in an adolescent.

Infection as a cause of ankylosis may arise following scarlet fever, from perforation of the tympanic plate of bone in *otitis media*, from a parotid abscess perforating the capsule; in one of my cases in which the ankylosis was bilateral, it was said to have followed "rat bite fever".

The temporo-maxillary joint may also be one of the joints involved in rheumatoid arthritis, as occurred in another case in which ankylosis was bilateral, the cervical vertebræ being also involved. Ankylosed joints following infection are apt to exhibit considerable destruction of cartilaginous surfaces and massive fibrous tissue formation in and around the joint. For all practical purposes there is no difference between what the textbooks call fibrous and what they call osseous ankylosis, and prior to operation it is often quite impossible to say which is present. To anyone who has not seen the fact demonstrated at operation, it may be difficult of belief that when a joint is completely ossified by dense bone formation between the root of the zygoma and the neck of the condyle, a slight amount of movement of the jaw and separation of the teeth are still possible. The springiness of the zygomatic arch is the only possible explanation.

It is not possible to tell from skiagrams whether "osseous" or "fibrous" ankylosis is present, and it is quite immaterial (except that the operation may be much more prolonged in dense osseous ankylosis), because in both, for all practical and also surgical purposes, the joint must be considered as non-existent.

SECONDARY DEFORMITIES.

Although the growth of the patient may not be limited by a gradual oncoming ankylosis of the jaw, the development of the latter certainly is. The earlier the ankylosis occurs, the more infantile the jaw remains, giving a typical rodent-like facial appearance in profile. This is well recognized, but what is often not noted, and is often of diagnostic importance, is a distinct bend in the lower border of the jaw at the anterior border of the masseter muscle, producing a marsupial type of jaw (Figure I). This bend, though

not so marked, can sometimes be felt in rhachitic children, but I have never seen a case of prolonged ankylosis in a child without it. If the ankylosis is bilateral, the bend or wide notch is equal on both sides; if the ankylosis is unilateral, the bend is more palpable on that side.

This deformity and the retrusion of the chin are due to the exaggerated efforts of the depressor muscles of the jaw, acting on the inner and lower borders of the symphysis in an endeavour to overcome the gradually restricting force of the ankylosis. A further, and the most serious, secondary effect is on the muscles of mastication, producing in them after the lapse of years (ten or fifteen) a fibrotic condition preventing relaxation. Forcible opening of the mouth then only tears the muscles, the tears cause much pain, and therefore rest and disuse, until the formation of scar tissue further and more firmly limits movement. Stereoscopic radiographs may in such cases show fine streaks running in the direction of the fibres of the masseter and temporal muscles, indicating calcareous deposits similar to those seen in *myositis ossificans*.

FIGURE II. Skiagram of ankylosed temporo-mandibular joint, due to direct trauma. Shows an apparent joint cavity, yet at operation (see Figure III) there was a massive osseous bar uniting condyle and zygoma.

It is doubtful therefore in a case of ankylosis of long standing in an adult whether surgical intervention is indicated, because all the muscles on both sides are liable to be so affected, and even if an Esmarch operation were done, function would be negligible. I have had one such case in which even after arthroplasty of the joint had been done no benefit resulted.

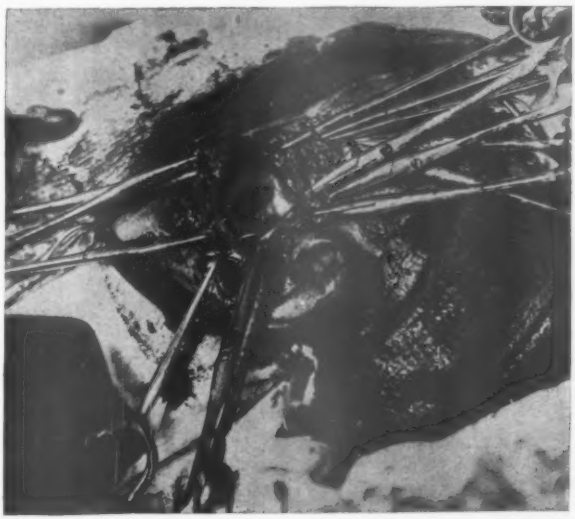


FIGURE III. Photograph taken during arthroplasty of the temporo-maxillary joint, showing presence of an osseous bar between jaw and zygoma, yet the X-ray examination rather indicated a "fibrous" ankylosis (Figure II). Exposure by excision of scar tissue.

FIGURE IV. Massive osseous ankylosis of the temporo-mandibular joint and sigmoid notch to base of skull, which was bilateral. Arthroplasty had to be abandoned on account of the depth of new bone formation. Sufficient access was impossible without division of the facial nerve.

FIGURE V. Skiagram showing result of Esmarch's operation (bilateral) done in case shown in Figure IV. Result unsatisfactory.

DIAGNOSIS.

That fixation of the jaw is present is of course obvious, but the exact point of fixation may be difficult to determine. No help on this point is to be looked for from the patient. Some assistance as to the side on which the fixation is present may be obtained from the history and also from the depth of the bend in the lower border of the mandible. The best method of palpation is to put the tip of a little finger in the auditory meati on both sides and ask the patient to try to move the jaw up and down and from side to side. It may then be possible to detect a slight difference in the condylar movements on each side.

RADIOGRAPHIC EXAMINATION.

Radiographic examination is admittedly difficult. It seems that

the more the radiologist tries to get a clear picture of the temporo-mandibular joint, the less likely he is to be successful; whereas when something else is being investigated, a beautifully clear picture of the joint unexpectedly appears. The fact that the jaw is small and fixed renders the radiologist's task no easier. Further, when a good clear picture (that is, one not superimposed by some other structure) is obtained, there is little to be seen even when subsequent operation reveals an osseous ankylosis (Figures II and III). The rule I have come to rely on is that in a good skiagram of a normal temporo-mandibular joint the outlines of the glenoid fossa and superior surface of the condyle should be quite clear and separate; the least fuzziness means either massive scar tissue and erosion of cartilage or new osseous tissue, the later not being very radio-opaque. If no space at all is visible where the inter-articular fibre cartilage should be, it may be taken for granted that there is much new bone formation. A skiagram taken with the patient in the ordinary mastoid position will often give a better result than others.

FIGURE VI. Ankylosis of the jaw following scarlet fever. The upper incisor teeth had been extracted to facilitate feeding, but the increasing force of contraction is shown in the way the lower incisors are being forced forwards. History of osteotomy of the neck of the condyle having previously been done, relief was very temporary.

FIGURE VII. Result eight weeks after arthroplasty of the temporo-mandibular joint, with the use of temporal muscle and fascia. Compare Figure VI.

Extraarticular adhesions may be present between the coronoid process and the zygoma or the lateral wall of the skull and the coronoid. These cases,

FIGURE VIII. Photograph of patient shown in previous two figures to illustrate that no facial paralysis has resulted, and also that it has been possible for her to have satisfactory dentures fitted.

however, are usually traumatic and the situation of a scar may give a clue to the position. Nevertheless one occasionally encounters cases of most difficult diagnosis.

I have one such patient under observation at present, a boy of ten years, who has had fixation of the jaw for three years; the history is completely negative. Skiagrams have been taken by three expert radiologists —all with negative reports. I have explored both temporo-mandibular joints and can find no signs of ankylosis, yet even under an anæsthetic fixation is rigid. We shall probably get a "lucky" skiagram one day which will unexpectedly reveal the site of the fixation.

FIGURE IX. Ankylosis of the right temporo-mandibular joint following a fall down some steps three years previously. The boy is trying hard to "open his mouth wider".

FIGURE XI. Result of arthroplasty of the temporo-mandibular joint with the use of temporal fascia. Compare Figure IX. Good up and down—pure hinge—movement, but no lateral movement, and jaw comes to a sudden stop.

FIGURE X. Skiagram of the case shown in Figure IX. It apparently shows a dense osseous ankylosis, but at operation it was nothing like so dense as was anticipated.

OPERATION.

There are the two well-known operations: Esmarch's and arthroplasty. The removal of a wedge of bone from the angle of the jaw (Esmarch's operation) is obviously much the easier means of relieving the fixation, but it is not rationally sound because it does not attack the *fons et origo mali*. It has other disadvantages, namely: (1) It completely robs the patient of the use of the temporal and the internal pterygoid muscles, and of the

greater part of the masseter muscle on that side. (2) It greatly interferes with the growth of the mandible, producing almost complete cessation on that side. (3) The space, even with muscles sutured between the bone ends, is difficult to maintain, because of the strong circular forward pull of the temporal muscle on the upper part of the mandible. (4) Owing to the unopposed action of the depressor and retrusor muscles on the side that has been operated on, the chin swings round to that side and the occlusion of the teeth is upset. (5) The mandibular artery vein and nerve are divided and regeneration of the nerve is impossible if something is interposed or if the two orifices of the canal do not meet, and it is mechanically impossible that they should (Figures IV and V).

FIGURE XII. Ankylosis of jaw, right side, following middle ear disease four or five years previously. The ankylosis was of a springy nature. No mastication whatever was possible, yet the boy was thriving well.

FIGURE XIV. Voluntary opening possible sixteen days after arthroplasty of the temporo-mandibular joint. Same case as illustrated in Figure XIII.

FIGURE XIII. Skiagram from the patient shown in the previous illustration, showing dense ankylosis of the right temporo-mandibular joint.

Arthroplasty.

The difficulty of arthroplasty lies in the extreme limitation of access. For a long time I have employed a vertical incision close to the ear, running

FIGURE XV. Ankylosis of jaw due to intracapsular telescopic fracture caused by a fall in infancy. Maximum opening seven millimetres.

for three-quarters of an inch below the zygoma, and about two inches above the zygoma, together with an incision at right angles along the zygoma for three-quarters of an inch. It is impossible to make these two three-quarter-inch incisions any longer without damaging the nerve to the *orbicularis occuli*, and even with only three-quarters of an inch, the nerve to the occipito-frontalis is often cut. This, however, does not much matter, and the patient or parents are warned of it beforehand. Retraction of the wound downwards, which always has to be done, produces some temporary paresis of the nerve to the orbicularis, but from this it recovers in a fortnight or so. Thus one is limited to operating through an incision whose longest practical diameter is only one inch. The next limitation is the internal maxillary artery, which winds round the neck of the condyle from the termination of the external carotid. The greatest care has to be taken not to wound this artery, since it is from its position very difficult or impossible to pick up. In fact, after the superficial temporal vessels are ligated, endeavour should be made to wound no further vessels at all, or one finds one's self trying to operate at the bottom of a well of blood.

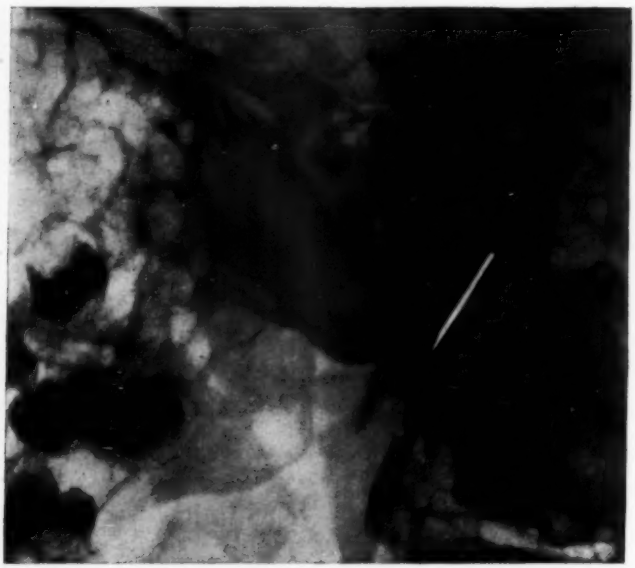


FIGURE XVI. Skiagram of the left temporo-mandibular joint of boy shown in previous figure. Operation revealed an old intracapsular impacted fracture and totally disorganized joint, which could not be fully diagnosed from the skiagram.

Further disadvantages of the ordinary arthroplasty, whether temporal fascia or *fascia lata* is interposed, is that firstly the ramus of the jaw is

necessarily shortened appreciably on that side; this alters the plane of the occlusal surfaces of all the lower teeth, whereas the upper teeth of course remain stationary—that is to say, the lower jaw and teeth are, in relation to the upper jaw, slewed round and up by a distance equal to the amount of bone removed.

The second shortcoming of the usual arthroplasty is that a pure hinge joint is produced, with perhaps a good upward and downward movement and a satisfactory opening between the front teeth, but no lateral movement, and there remain an unnatural stiffness about the jaw movements and a curious sudden stop when the mouth is opened, for which I have been unable to account.

It may be contended that these are the lesser of two evils, and that compared with an immobilized jaw they are trivial; but the whole object of the operative procedure is to give the patient as normal function as possible and free from any disabilities. With this object in view I have carried out the following technique:

FIGURE XVII. Exceptionally free movement of jaw after cartilage graft restoration of joint. Voluntary opening 34 millimetres. Compare Figure XV. Photograph taken seven months after operation. No "sudden stop" when mouth is widely opened.

1. A Z-shaped incision is made. The upper limb of the Z runs along the zygoma for three-quarters of an inch, and the lower runs inwards into the auditory meatus through the lower portion of the antihelix, and the two limbs are joined by a slightly diagonal incision. This gives a very much better exposure. Everyone seems to have carefully avoided the meatus previously, but given a thorough toilet and with the use of "Metaphen" or similar preparation, there is no reason why it should not be utilized for access to the posterior and medial aspects of the neck. The proximity of the termination of the external carotid and the internal maxillary arteries must always be remembered. For this reason the incision must be made very carefully below the skin and cartilage.

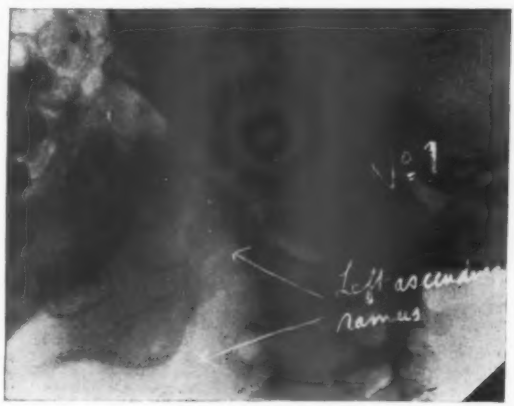


FIGURE XVIII. Skiagram of the left temporo-mandibular joint of boy shown in the previous figure after cartilage graft restoration of the joint. The cartilages of course do not show, but the normal appearance of the condyle is evident. (Note the bend in the lower border of the mandible.)

2. After the two resulting triangular flaps are well retracted and a neck of the condyle is exposed, a Rose's cleft palate raspatory is passed round behind it, closely hugging the bone; this serves to clear away the internal maxillary vessels and subsequently protect them.

3. By means of a broad ligament needle on which it is threaded, a Gigli saw is passed similarly round the condyle. It may or may not be necessary

for this to remove the raspatory, but, in any case, it must be reinserted before the Gigli saw is used. The neck is then rapidly divided and the ankylosed condyle is levered out of the glenoid fossa. The advantage of this method over the use of burs, chisels and rongeurs is obvious.

4. The next procedure is to remove two pieces of suitable rib cartilages, about one inch long. These are each stripped of their perichondrium along one surface; and then one is shaped to fit the glenoid fossa, perichondrium surface upwards; the other is shaped to fit the neck of the condyle, perichondrium surface downwards, to represent a new condyle. These cartilage grafts are then sutured into place with silk and the wound is closed without drainage.

The suitability of cartilage grafts here is very clear.

1. They interpose in amount and character a tissue very "like" that removed.

2. By their use the anatomical arrangements for masticating are properly restored.

3. Rib cartilage here is well adapted for the purpose, because perichondrium is extremely adherent. It forms adhesions with other tissues more quickly and more densely than any other tissue with which I am acquainted in grafting operations. For instance, when a piece is buried in the fat of the abdominal wall for future use, in a fortnight it is found that the perichondrium has formed such dense adhesions to the fat that it is somewhat difficult to remove, and anyone who has had to remove a cartilage graft from a nose (because perhaps of its unsatisfactory shape) will know how tedious a matter it can be.

The opposing surfaces are of naked cartilage, and this of all substances is the least adherent, and it is the one and only substance on which it is possible to make a razor skin graft "take".

REMARKS ON THE POST-OPERATIVE PERIOD.

The jaw is kept still for ten days and then active mastication is encouraged. There is no pain at all, and if the patient is a boy and apples are provided, there is no difficulty whatever.

Subsequently there is a great difference observable between the fascia type of arthroplasty and this.

The movements of the jaw are quite free and natural; it can be moved not only as a hinge, but also from side to side; there is no sudden stop on opening the mouth, and the alignment of the lower jaw and teeth is normal. When the patient is told to "let his jaw go loose" and one manipulates the jaw with thumb and finger on the chin, the smooth, gliding, natural motion of both sides of the jaw are very observable, compared with the movements after the fascia type of arthroplasty.

It seems clear that cartilage graft restoration of the temporo-mandibular joint can give functional results not, I think, hitherto obtainable.

THE USE OF KANGAROO TENDON FOR MUSCLE AND TENDON SUTURE.[1]

By E. R. Trethewie and Eleanor Williams.[2]

(From the Walter and Eliza Hall Institute, Melbourne.)

Introduction.

Nearly a century has passed since kangaroo tendon was first used in suturing, and in view of its strength, interest has been reawakened in the possibility of using this tendon obtained from the marsupial's tail. In this paper we report experimental tests on this material when used in muscle and for repairing tendon.

Method.

Tendon from the kangaroo's tail was placed in cold water for six hours and then cleaned and soaked in methylated spirits (S.V.M.) for two to three days. It was then split to size with the finger-nail, dried between clean towels and placed in ether for twenty-four hours. It was next put in an iodine solution (iodide of potash, 2%; iodine, 1%, and iodate of potash, 0·25%, in water) for nine days, and then placed in 75% spirit for one day, at the end of which it was transferred to fresh 75% spirit for a second day. The following day it was placed in 85% spirit and later stored in a 0·1% iodine solution in 85% alcohol containing glycerine, 2%.

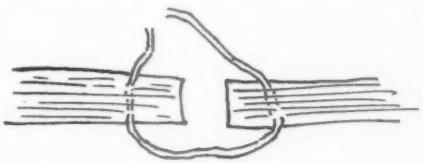


Figure I. The method of tendon suture employed.

In guinea-pigs anæsthetized with ether, full aseptic precautions being used, sutures were buried in the *erector spinæ* muscle through a dorsal skin incision. The *tendo Achillis* was also exposed and divided and the ends united as in Figure I; sometimes a reinforcing suture was required. A splint was then applied to the limb.

The tensile strength of kangaroo tendon before implantation was determined as is that of catgut after a simple knot has been tied in it. In tendon removed at various times after implantation a rough estimate of the tensile strength was made, the unknotted material being used. Stout string was attached to each end by lashing with fine twine and the tendon was suspended vertically and weights were applied to a platform attached to its lower end. The weight required to break the tendon was taken as its tensile strength.

Results.

Implantation in Muscle.

Kangaroo tendon buried in muscle undergoes little change in general appearance when it is removed at varying intervals up to three months. There is only slight swelling, but the knots remain tied. After longer intervals it becomes increasingly difficult to remove the suture material intact from the muscle, owing to organization of firm fibrous connective tissue around the

[1] Accepted for publication on September 29, 1941.

[2] This work was aided by a grant from the National Health and Medical Research Council.

knot on the outer surface of the muscle. Despite the slight change in the appearance of the tendon, its tensile strength diminishes during the first four weeks to 20% to 25% of its original value. Thereafter the fall is more gradual, diminishing to 10% at the end of three months (see Table I).

TABLE I.

Time Kangaroo Tendon Left *in situ*.	Tensile Strength. (Grammes.)	
	Before Implantation in Muscle.	After Implantation in Muscle.
2 weeks	3,400	1,800
2 weeks	3,400	1,900
4 weeks	2,700	550
4 weeks	3,400	700
7 weeks	3,400	700
7 weeks	3,400	800
12 weeks	3,400	360
12 weeks	3,400	410

Implantation in Tendon.

In striking contrast to the effects produced in muscle, there is rapid disappearance of the suture material when it is implanted in tendon. In eight guinea-pigs examined macroscopically from one to three months after its introduction no trace of the suture material could be found. In one animal two small subcutaneous ends from the tie were lying detached from the tendon at four weeks, and the portion within the tendon had been absorbed.

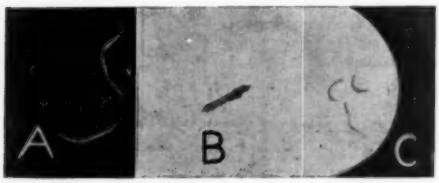


FIGURE II. Comparison of kangaroo tendon. A = before use, B = after implantation in *erector spinæ* muscle for three months, C = after implantation in *tendo Achillis* for two weeks (natural size).

Even in the short space of two weeks there was much digestion of the suture material, the portions removed from the tendon being wispy and fragmented (C in Figure II). In the same figure, for comparison, a piece of fresh kangaroo tendon of identical original size from the same stock (A) and a similar piece which had remained in the *erector spinæ* muscle for three months (B) are shown.

DISCUSSION.

The striking difference between the changes in kangaroo tendon implanted in muscle on the one hand and in tendon on the other is difficult to explain. Since the hind limb containing the sutured tendon was splinted, it is unlikely that greater movement of the tendon in its sheath was responsible; and though stresses on the suture material in tendon might well be greater than those in the depths of the *erector spinæ* muscle, this cannot be held to explain the observed difference in behaviour. Possibly it depends on a fundamental difference between the fluids bathing the suture material in the two cases, and it may be that synovial fluid contains enzymes specifically adapted to dissolving dead tendon. Whatever the explanation of the rapid absorption of the suture material, this phenomenon may explain why poor results are so often obtained even in clean cases after suture of divided tendons.

The Australian and New Zealand Journal of Surgery.

All articles submitted for publication in this journal must be typewritten and double or treble spacing should be used. Each article should conclude with a brief summary and statement of conclusions. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

Authors are requested to submit two typescript copies of all articles.

References to articles and books should be carefully checked. In a reference the following information should be given without any abbreviation: initials of author, surname of author, full title of article, name of journal, volume, full date (month, day and year), number of the first page of the article. If a reference is made to an abstract of a paper, the name of the original journal, together with that of the journal in which the abstract has appeared, should be given, with full date in each instance.

When illustrations are required, good photographic prints on glossy gaslight paper should be submitted. Line drawings, charts, graphs and so forth should be drawn on thick white paper in indian ink. Authors who are not accustomed to prepare drawings of this kind, are invited to seek the advice of the Editor if they are in any doubt as to the correct procedure. Skiagrams can be reproduced satisfactorily only if good prints or negatives are available.

VOL. XI. JANUARY, 1942. No. 3.

WAR-TIME SURGERY.

READERS of this journal will welcome the articles in this issue from Australian surgeons serving with the Australian Army Medical Corps abroad. The ground covered by these papers is extensive and all who read them will gain some insight into the type of problem facing the present-day war surgeon and the mental and technical equipment with which he must be endowed. The problems are not essentially new; they had to be faced with grim earnestness in the war of 1914-1918, of which in truth the present struggle seems but to be the continuation. B. K. Rank in his discussion on the base hospital management of soft tissue injuries puts the matter in a nutshell when he writes that "many battle casualties are still potential fighting men and it is essential that maximum functional results are obtained in minimum time". It is as well to realize that the primary duty of medical officers with the fighting forces is to maintain those forces as far as possible at their full fighting strength. With this object in view it is essential to give preference to those battle casualties who can be returned to duty within a reasonable time and so to arrange their hospital treatment as to secure the most rapid return to full duty. However much the surgeon's sympathies go out to gravely wounded men, such as those with abdominal wounds referred to by Julian Smith, with their 54% mortality and the total unfitness for service of the 46% who recover, such cases must be subordinated to the better risks who can be returned to their units within a short time. This reorientation, this change of mental attitude, by which the preservation of the soldier as a fighting unit assumes prime importance, is not always easily attained. It has been shown in the past that such attainment is possible without sacrifice

of the qualities that go to make a faithful surgeon, although he may have to jettison much of the technical details and proprieties of civil surgery; and the writers of the articles now presented show that their ideas have had to be recast to meet the changing demands of surgery in modern warfare. War surgery demands not only skill in the treatment of the injury *per se*, but also an understanding of the power of the body tissues to recover function lost through the violence of war and of the ability of the nervous system to withstand shock and deprivation. Of the skill needed in the actual treatment of wounded men, Julian Smith gives ample indication. Resource, quickness in decision, speed of execution and ability to withstand the stress of long periods of concentrated work are called for and are indispensable to the successful practice of war surgery. The war surgeon, more than his brother in civil practice, needs to be acquainted with the whole field of medicine, to approach his task with the mind of a physician and to be prepared to turn his energies in any direction.

There is no need in the present instance to discuss in any detail the several contributions appearing in this issue. The point that should be made is that they must be looked on as reporting the experiences of individual surgeons in certain theatres of war and are not necessarily to be accepted as providing material from which general conclusions can be drawn. For example, when Julian Smith reports the excellent results he has obtained with sulphanilamide treatment and the absence of gas gangrene, it must not be assumed that the same findings would be obtained in any theatre of war. The kind of country over which the action has been fought has a distinct bearing on the incidence of gas infection of the tissues. In the present war reports from several sources in the Middle East have shown that gas gangrene occurs more readily after a heavy downpour of rain. It would be unreasonable to expect the incidence of this type of infection to be the same in the Western Desert as, for example, in country like Malaya or in a terrain such as the churned up fields of Flanders of the last war. Even if the incidence of gas gangrene was different in other places, the beneficial results of the use of sulphonamide compounds might still, of course, be the same. It may also be useful to call attention to the doses of "M & B 693" given in Julian Smith's unit. Every wounded man on admission was given four tablets or two grammes; this dose was followed by one gramme every four hours. In some field ambulances an initial dose of five grammes was given, and in some base hospitals the administration of a daily dose of the same size was the routine practice. In this connexion it is of interest to recall the work of Roderick Andrew, of the Australian Army Medical Corps (*The Medical Journal of Australia*, November 29, 1941, page 612). Andrew studied three groups of patients and gave them nine, six and four grammes of sulphapyridine on successive days at dosage intervals of four, twelve and twenty-four hours. Approximately equivalent concentrations of sulphapyridine in the blood were found in the three groups. Andrew found that administration every twelve or twenty-four hours was practicable for immediate prophylactic use and during the evacuation of casualties.

The vital importance of blood transfusion in the forward areas is stressed and confirms the experiences of the Great War and the work so ably initiated by Alan Holmes à Court. We now have dry serum and plasma to supplement this procedure, but although they have a definite value in combating shock from burns, they cannot replace actual blood loss. Owing to the difficulties in collecting wounded in mechanized warfare and the delay in bringing them to efficient surgical units, the primary suture of wounds as practised in the last war can seldom be employed, as its success depends on the initiation of treatment within eight hours of the infliction of the wound. For a similar reason *débridement* takes on a new meaning and must have only a limited application.

C. W. B. Littlejohn stresses the need for conservatism in the treatment of chest wounds and the supreme importance of early and efficient closure of sucking wounds. B. K. Rank confirms other observers in the important part played by the hæmolytic streptococcus in the delayed healing of wounds. He has found that 63% of the patients admitted under his care were already infected with these organisms and that they were the main cause of what he refers to as chronic wounds. The local use of sulphanilamide powder in such cases is enthusiastically supported, as well as its application in recent wounds, by most surgeons at the front. Opinions vary as to the oral administration and dosage of the sulphonamides, but most observers recommend it. The role of vitamin *C* in wound healing is receiving prominence and is doubtless recognized in the increased dietary scale allowed to the troops in general. The use of the tanning preparations for the treatment of burns is a subject on which there is by no means any general agreement other than that such substances are better not used on the face, hands and flexure areas. Recent experiences show that cod liver oil with acriflavine or any other oily emulsion with this dye is highly efficient and should replace the tan methods at least on the face, hands and flexure creases.

It is to be hoped that the present contributions from surgeons serving abroad are but the harbingers of others to follow very quickly, as such practical experience is most valuable. Information of this kind should be made available to the profession as a whole both in Australia and New Zealand, especially since in both Commonwealth and Dominion medical men are liable to be called up for service with the Defence Forces and the threat of war on our own homeland is so close at hand.

H. R. G. POATE.

Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

TOMOGRAPHY OF THE LARYNX AND TRACHEA IN RELATION TO THYREOIDECTOMY.

Dr. O. Schürch (Winterthur): *"Schichtaufnahmen von Kehlkopf, Trachea und Strumektomie", Der Chirurg,* July 15, 1939.

Schürch opens his paper by discussing the difficulty there is in obtaining sufficient information about the detailed condition of the larynx and trachea in the investigation of some patients needing thyreoidectomy and having pressure on the trachea. In the presence of chronic tracheitis and stenoses, intratracheal manœuvres of any sort are inadmissable, and indirect laryngoscopy does not give the required information as to the deeper parts. He has therefore developed the "tomographic" or "plane" radiographic technique, as described by Gunsett and Greineder, by which accurate radiograms of the vocal cords, the ventricular bands, the sinuses of Morgagni and the subglottic region were obtained in good films of the larynx and the trachea.

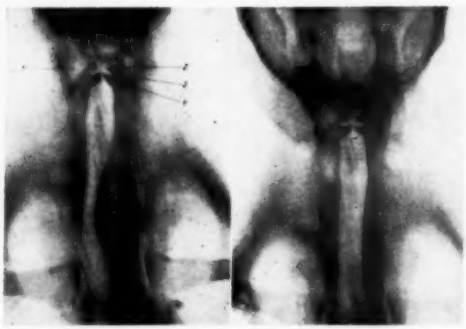


Figure I. Figure II.

Figure I: Goitre with severe narrowing of the trachea. Larynx normal. 1 = pyriform sinus; 2 = ventricular band; 3 = sinus of Morgagni; 4 = vocal cord.

Figure II: Same patient as shown in Figure I after thyreoidectomy.

If serial sectional films are taken of a larynx in the antero-posterior position, one finds first at an average distance of one centimetre behind the Adam's apple the hyoid bone, the pyriform sinus, the glottis and the subglottic space. Ventricular bands and vocal cords are not yet in view. By taking films one centimetre further back all the characteristic features of the larynx come into clear view: both ventricular bands, both vocal cords and between them the sinus of Morgagni on both sides, with the subglottic region below. Above the ventricular bands and laterally to them are seen the pyriform sinuses, ordinarily in sharp definition, and thrown into sharper relief by phonating in "O". As films are taken farther backwards, the outlines of the cervical vertebræ become clearer, the epiglottis is clearer, the pyriform sinuses are still visible, but the characteristic "key" pattern of the laryngeal section is lost. The sinuses of Morgagni stand out between the two folds on either side, and the arytenoid cartilages begin to show up through the ventricular bands. The vocal cords and the ventricular bands naturally vary a good deal in shape, according to whether the film is taken in inspiration or expiration, in silence or in phonation, and, if in the latter, in what tone. Gunsett and Greineder demonstrate in their films that the actual width of the glottis remains the same in all tones of phonation, and that there is no real slackening of the cords. The

Figure III. Figure IV.

Figure III: Right vocal cord paresis in phonating "A".

Figure IV: Same patient in phonating "E".

difference in the various tones lies much more in differences of configuration and in gross size of the sinuses of Morgagni, the pyriform sinuses, and the general laryngeal space above the cords.

Schürch then proceeds to demonstrate by films how well adapted this technique is for investigation before thyreoidectomy, and how the various points which are of importance to the surgeon are almost always made visible by this method.

Four figures here reproduced illustrate well the excellent and unusual view of the laryngeal structures and their relations.

The following is a note on the technique. The apparatus used is Siemens's planigraph with a Pantix tube of 40 kilowatts, a focal distance of 150 centimetres, a milliamperage of 200 and a kilovoltage of 70. The exposure time is one second.

The patient sits with his back against the wall support, with his occiput resting against it. The chin is in a sling, neither raised nor lowered unduly. The operative plane of the tomograph should be 1·5 to at most 3·5 centimetres behind the Adam's apple. No greater movement of the plane than 0·5 centimetre should be necessary. Generally two planes are sufficient, the first as nearly as possible through the centre of the larynx, to show up the cords as sharply as possible. The exposure is made during phonation of either "E" or "A" sounds. When this investigation is made for purposes of thyreoidectomy, the tube should be centred over the larynx, but the film centred a good deal lower to get the lower part of the trachea well in view.

ARTHUR E. BROWN.

CHRONIC MALIGNANT GRANULOCYTOPENIA TREATED WITH SPLENECTOMY: RECOVERY.

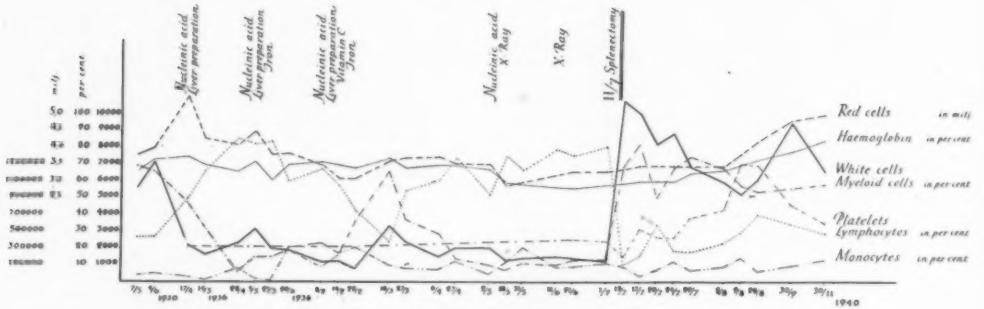
N. G. Nordenson and S. Roden (from the Medical and Surgical Services of the Caroliner Hospital, Stockholm, Sweden; Chiefs: Professor Nanna Svartz and Professor J. Hellstrom): *Acta Chirurgica Scandinavica*, Volume lxxxiv, Fasciculus vi, May 15, 1941, page 519.

CHRONIC malignant granulocytopenia runs a chronic course. The patient is easily exhausted, is subject to necrotic ulcerations in the various mucous membranes, and presents a blood picture of chronic leucopena with a certain degree of anæmia which, in late stages of the disease, may be that of the aplastic type. The pathogenetic basis is a disturbed maturation of the myeloid system in the bone marrow in which myeloblasts, promyelocytes and myelocytes predominate. The marrow is not empty like the marrow in acute granulocytopenia; it is filled with cells, but maturation is arrested. Although nucleinic acid and its derivatives are stimulants of the myeloid maturation, it has only had a limited effect in granulocytopenic states and has seldom caused any marked improvement. The spleen plays an important part in the complete development of myeloid cells, and there seems to be an antagonistic relation between the spleen and the bone marrow. The leucocytosis and erythrocyte increase and thrombocytosis which are found following splenectomy, can be explained only by the assumption of the removal of an influence which is inhibitory to bone marrow hæmopoiesis and which has been mediated by or through the spleen.

Nordenson and Roden studied a case of chronic malignant granulocytopenia over a period of four years. The patient showed a marrow full of cells, but with a typical disturbance of the myeloid maturation process. The patient had had polyarthritis and had been treated by exposure to X rays and the administration of remedies containing amidopyrine. The differential count of the bone marrow was as follows:

Myeloblasts	7·1%
Promyelocytes	6·2%
Myelocytes	26·2%
Metamyelocytes	5·1%
Red forms	3·3%
Neutrophile cells	2·7%
Lymphocytes	29·3%
Monocytes	4·1%
Proerythroblasts	1·0%
Basophilic normoblasts	1·5%
Polychromatic normoblasts	2·3%
Orthochromatic normoblasts	5·6%
Megakaryocytes	0·1%
Reticular cells—	
Lymphoid	2·4%
Plasmacellular	2·8%
Phagocytic	0·3%

This patient had a persistent leucopenia, and finally suffered from anæmia. All forms of nuclein therapy failed to produce improvement. Eventually the patient came into hospital with acute œdema of the larynx and it was necessary to perform a tracheotomy. A few months later, when the patient had somewhat recovered, Nordenson advised splenectomy on the following grounds: that there was a pronounced maturation arrest of the myeloid system in the bone marrow, and that this was probably due to an inhibitory effect of the myelopoiesis caused by the spleen. In hæmolytic jaundice and essential thrombocytopenia, he argued, there is an analogous disturbance of the maturation process in erythropoiesis and thrombocytopoiesis, and in these conditions splenectomy is successful. In this case, if the bone marrow was still capable of functional response, splenectomy should be expected to release a fuller and more



Curve showing the haematological course of a case of chronic malignant granulocytopenia before and after splenectomy.

complete production of marrow cells. Splenectomy was accordingly performed. The spleen was enlarged, soft and fixed to its surroundings. Fourteen days after the operation the tracheotomy tube was removed, and the wound in the larynx healed normally. Four months later the patient was well, her blood was normal, and repeated sternal puncture yielded a normal marrow.

In this case X-ray treatment of the patient's polyarthritic joints, together with the administration of amidopyrine, had probably caused the granulocytopenia. The dominating symptom through the four years was extreme tiredness. The late symptom of œdema of the larynx was analogous to the changes of the mucous membranes seen in the acute type of malignant granulocytopenia. After splenectomy there was a striking and lasting improvement, not only of the hæmolytic changes, but also of the general condition of the patient. As far as the authors know, their case of splenectomy is the only one reported in literature for chronic malignant granulocytopenia. They suggest that splenectomy might be considered as a treatment in acute granulocytopenia.

H. B. DEVINE.

IS UROGRAPHY A RELIABLE AND VALUABLE AID IN OBTAINING A DIFFERENTIAL DIAGNOSIS IN ACUTE APPENDICITIS?

Dr. Helge. B. Wülff: *Acta Chirurgica Scandinavica*, Volume lxxxiv, Fasciculus v, March 29, 1941, page 414.

THERE is a type of acute abdominal emergency in which all the manifestations point to a lesion of the right side of the abdomen. The pain is severe, sometimes of a colicky nature, and not unlike that of renal colic. Tenderness and rigidity may not be marked. It is a question whether the condition is caused by renal colic, the result of a stone too small or too thin to show in a skiagram, or whether it is due to some anomalous form of appendicitis occurring in an appendix which is undescended, partially descended or retrocaecally situated; and in which findings, such as tenderness and rigidity, are often indefinite. In acute abdominal conditions such as these, an accurate diagnosis is urgently necessary because if the condition is acute appendicitis prompt operation is urgently necessary. On the other hand, should an abdominal operation be performed and the condition be caused by a small reno-pelvic or ureteral stone, an unnecessary operation has been performed on the patient. In circumstances such as these, Wülff employs urography to eliminate the possibility of renal or ureteral colic. With the aid of this method he is able to make a prompt diagnosis. Success, he writes, depends upon making such an examination during an acute attack. After extensive investiga-

tions, Wülff found that urography gave normal findings in most abdominal disorders whose symptoms resemble those of reno-ureteral colic, conditions which cause compression of one or both ureters being excepted. In particular, his observations showed that in 31 cases of appendicitis, 23 of which were directly confirmed by operation, urographic findings were normal.

Wülff quotes Boeminghaus as writing that since 1929 he had never failed with urographic investigation to make correct differential diagnosis between colic arising from reno-ureteral calculus and acute appendicitis or inflammation of the uterine adnexa. In contrast to this, he quotes Arnesen as writing that in eight out of 34 cases of acute appendicitis, urographic findings suggestive of pelvo-ureteral disturbances were found. In these eight there was a slight dilatation of the pelvis of the kidney and of the upper part of the ureter, and a somewhat delayed elimination with a consistent filling of the upper two-thirds of the ureter—exactly the same manifestations which are seen in a late stage attack of ureteral calculus. In the cases in which these urographic changes were found, gangrenous appendices lay near the ureter.

According to Wülff, the normal urographic picture is: a rapid elimination of the contrast medium simultaneously on both sides; an equilateral filling of "a physiological pelvis and a physiological ureter"—that is, a filling of cavities the size and shape of which change according to the stage of peristalsis present when the X-ray picture is taken. He explains that deviations in the size of the pelvis and the width of the ureter normally occur because of the rapidity with which the size and shape of the pelvis of the kidney and the ureter can change, probably owing to the fact that the pelvis and the ureter are not usually filled with urine all the time, but only in certain parts which fill with urine according to the stage of peristalsis. Wülff explains Arnesen's observations of urographic changes in certain cases of acute appendicitis on the basis that they are a "diastolic phase" in the filling of the right pelvis of the kidney and ureter at the moment that the exposure to the X rays was made. There are, however, he writes, isolated cases of acute appendicitis in which urographic changes may be found. These are caused by spasm, by intraperitoneal or extraperitoneal inflammatory processes in the region of the right ureter, or by adhesions or stenosis the result of a previous attack of appendicitis.

Wülff has now collected 59 cases of acute right-sided abdominal lesions, the incidence of which was mostly high on the right side. In many of the cases a gangrenous appendix lay near or directly on the right ureter. In all the urographic findings were normal, the elimination of the contrast medium taking place equally on both sides, and the pelves and ureters not being dilated. Wülff concludes that urography is a reliable aid in the differential diagnosis of obscure acute abdominal conditions situated on the right side. Among cases whch he cites as example of the value of the method is the following. A man, aged sixty years, who in 1934 had a ureteral calculus on the right side—a concretion of the size of a grain of hemp in the right ureter near the bladder—became ill at 10 o'clock one night, suffering from diffuse abdominal pains which, half an hour later, became very severe and localized in the right side of the abdomen. His temperature was 37° C. and his pulse rate 80 in the minute. Tenderness and rigidity were present over the right side of the abdomen. Many red blood corpuscles were present in the urine. Another ureteral calculus was suspected. Urography revealed a normal picture. An operation was immediately carried out and a gangrenous appendix was found.

H. B. DEVINE.

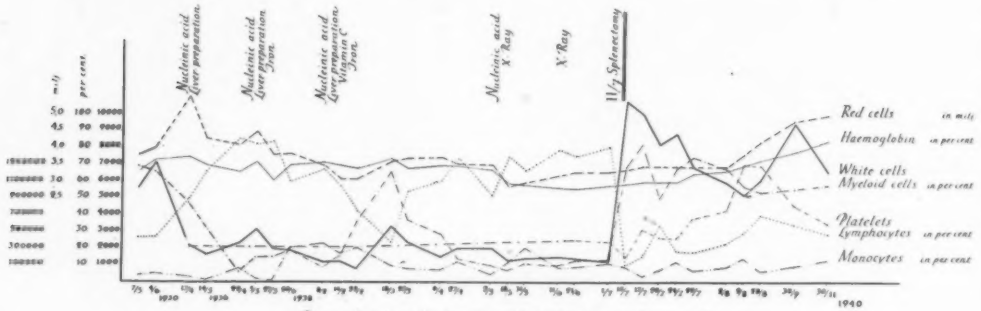
DOUBLE GALL-BLADDER.

Erik Millbourn: "*Über die doppelte Gallenblase, im Anschluss an zwei beobacstete Fälle*", *Acta Chirurgica Scandinavica*, Volume xxxiv, August, 1940, page 97.

MALFORMATIONS of the bile passages, though not frequent, cannot be described as rare. In fact Mentzer has put forward the figure of 10% as being an index of their relative frequency. But among them the double gall-bladder is one of the rarer forms. Millbourn has collected reports of 58 cases, among which are two of his own, the diagnoses resting variously on operative, post-mortem, and radiological findings. He estimates from these that their incidence is approximately one in 4,000 cases, but considers that they are probably rather more common than that, owing to the difficulty in establishing the diagnosis. At operation the condition can be missed; and among the number of cases in which the gall-bladder is investigated radiologically, there must be some in which one of the two organs is diseased, and the consequent single shadow, indicating a healthy gall-bladder, represents only the undamaged one of the pair.

Anatomically the abnormality is grouped into two main types: one in which the gall-bladder is actually duplicated, termed "*vesica fellea duplex*"; and the other in which it is just divided, "*vesica fellea divisa*". The first group is further subdivided into two types according as to whether the cystic ducts have two separate or one conjoined opening into the common duct. The second group is similarly subdivided according

This patient had a persistent leucopenia, and finally suffered from anæmia. All forms of nuclein therapy failed to produce improvement. Eventually the patient came into hospital with acute œdema of the larynx and it was necessary to perform a tracheotomy. A few months later, when the patient had somewhat recovered, Nordenson advised splenectomy on the following grounds: that there was a pronounced maturation arrest of the myeloid system in the bone marrow, and that this was probably due to an inhibitory effect of the myelopoiesis caused by the spleen. In hæmolytic jaundice and essential thrombocytopenia, he argued, there is an analogous disturbance of the maturation process in erythropoiesis and thrombocytopoiesis, and in these conditions splenectomy is successful. In this case, if the bone marrow was still capable of functional response, splenectomy should be expected to release a fuller and more



Curve showing the haematological course of a case of chronic malignant granulocytopenia before and after splenectomy.

complete production of marrow cells. Splenectomy was accordingly performed. The spleen was enlarged, soft and fixed to its surroundings. Fourteen days after the operation the tracheotomy tube was removed, and the wound in the larynx healed normally. Four months later the patient was well, her blood was normal, and repeated sternal puncture yielded a normal marrow.

In this case X-ray treatment of the patient's polyarthritic joints, together with the administration of amidopyrine, had probably caused the granulocytopenia. The dominating symptom through the four years was extreme tiredness. The late symptom of œdema of the larynx was analogous to the changes of the mucous membranes seen in the acute type of malignant granulocytopenia. After splenectomy there was a striking and lasting improvement, not only of the hæmolytic changes, but also of the general condition of the patient. As far as the authors know, their case of splenectomy is the only one reported in literature for chronic malignant granulocytopenia. They suggest that splenectomy might be considered as a treatment in acute granulocytopenia.

H. B. DEVINE.

IS UROGRAPHY A RELIABLE AND VALUABLE AID IN OBTAINING A DIFFERENTIAL DIAGNOSIS IN ACUTE APPENDICITIS?

Dr. Helge. B. Wülff: *Acta Chirurgica Scandinavica*, Volume lxxxiv, Fasciculus v, March 29, 1941, page 414.

THERE is a type of acute abdominal emergency in which all the manifestations point to a lesion of the right side of the abdomen. The pain is severe, sometimes of a colicky nature, and not unlike that of renal colic. Tenderness and rigidity may not be marked. It is a question whether the condition is caused by renal colic, the result of a stone too small or too thin to show in a skiagram, or whether it is due to some anomalous form of appendicitis occurring in an appendix which is undescended, partially descended or retrocaecally situated; and in which findings, such as tenderness and rigidity, are often indefinite. In acute abdominal conditions such as these, an accurate diagnosis is urgently necessary because if the condition is acute appendicitis prompt operation is urgently necessary. On the other hand, should an abdominal operation be performed and the condition be caused by a small reno-pelvic or ureteral stone, an unnecessary operation has been performed on the patient. In circumstances such as these, Wülff employs urography to eliminate the possibility of renal or ureteral colic. With the aid of this method he is able to make a prompt diagnosis. Success, he writes, depends upon making such an examination during an acute attack. After extensive investiga-

tions, Wülff found that urography gave normal findings in most abdominal disorders whose symptoms resemble those of reno-ureteral colic, conditions which cause compression of one or both ureters being excepted. In particular, his observations showed that in 31 cases of appendicitis, 23 of which were directly confirmed by operation, urographic findings were normal.

Wülff quotes Boeminghaus as writing that since 1929 he had never failed with urographic investigation to make correct differential diagnosis between colic arising from reno-ureteral calculus and acute appendicitis or inflammation of the uterine adnexa. In contrast to this, he quotes Arnesen as writing that in eight out of 34 cases of acute appendicitis, urographic findings suggestive of pelvo-ureteral disturbances were found. In these eight there was a slight dilatation of the pelvis of the kidney and of the upper part of the ureter, and a somewhat delayed elimination with a consistent filling of the upper two-thirds of the ureter—exactly the same manifestations which are seen in a late stage attack of ureteral calculus. In the cases in which these urographic changes were found, gangrenous appendices lay near the ureter.

According to Wülff, the normal urographic picture is: a rapid elimination of the contrast medium simultaneously on both sides; an equilateral filling of "a physiological pelvis and a physiological ureter"—that is, a filling of cavities the size and shape of which change according to the stage of peristalsis present when the X-ray picture is taken. He explains that deviations in the size of the pelvis and the width of the ureter normally occur because of the rapidity with which the size and shape of the pelvis of the kidney and the ureter can change, probably owing to the fact that the pelvis and the ureter are not usually filled with urine all the time, but only in certain parts which fill with urine according to the stage of peristalsis. Wülff explains Arnesen's observations of urographic changes in certain cases of acute appendicitis on the basis that they are a "diastolic phase" in the filling of the right pelvis of the kidney and ureter at the moment that the exposure to the X rays was made. There are, however, he writes, isolated cases of acute appendicitis in which urographic changes may be found. These are caused by spasm, by intraperitoneal or extraperitoneal inflammatory processes in the region of the right ureter, or by adhesions or stenosis the result of a previous attack of appendicitis.

Wülff has now collected 59 cases of acute right-sided abdominal lesions, the incidence of which was mostly high on the right side. In many of the cases a gangrenous appendix lay near or directly on the right ureter. In all the urographic findings were normal, the elimination of the contrast medium taking place equally on both sides, and the pelves and ureters not being dilated. Wülff concludes that urography is a reliable aid in the differential diagnosis of obscure acute abdominal conditions situated on the right side. Among cases whch he cites as example of the value of the method is the following. A man, aged sixty years, who in 1934 had a ureteral calculus on the right side—a concretion of the size of a grain of hemp in the right ureter near the bladder—became ill at 10 o'clock one night, suffering from diffuse abdominal pains which, half an hour later, became very severe and localized in the right side of the abdomen. His temperature was 37° C. and his pulse rate 80 in the minute. Tenderness and rigidity were present over the right side of the abdomen. Many red blood corpuscles were present in the urine. Another ureteral calculus was suspected. Urography revealed a normal picture. An operation was immediately carried out and a gangrenous appendix was found.

H. B. DEVINE.

DOUBLE GALL-BLADDER.

Erik Millbourn: "*Über die doppelte Gallenblase, im Anschluss an zwei beobacstete Fälle*", *Acta Chirurgica Scandinavica*, Volume xxxiv, August, 1940, page 97.

MALFORMATIONS of the bile passages, though not frequent, cannot be described as rare. In fact Mentzer has put forward the figure of 10% as being an index of their relative frequency. But among them the double gall-bladder is one of the rarer forms. Millbourn has collected reports of 58 cases, among which are two of his own, the diagnoses resting variously on operative, post-mortem, and radiological findings. He estimates from these that their incidence is approximately one in 4,000 cases, but considers that they are probably rather more common than that, owing to the difficulty in establishing the diagnosis. At operation the condition can be missed; and among the number of cases in which the gall-bladder is investigated radiologically, there must be some in which one of the two organs is diseased, and the consequent single shadow, indicating a healthy gall-bladder, represents only the undamaged one of the pair.

Anatomically the abnormality is grouped into two main types: one in which the gall-bladder is actually duplicated, termed "*vesica fellea duplex*"; and the other in which it is just divided, "*vesica fellea divisa*". The first group is further subdivided into two types according as to whether the cystic ducts have two separate or one conjoined opening into the common duct. The second group is similarly subdivided according

to whether the division is evident from the outside, or consists only of a septum halving the lumen.

Of the 58 cases collected by Millbourn, 37 were of the "*duplex*" group, 14 were of the "*divisa*" type, and in seven the details given were too scanty to allow of their being allotted definitely to either group. Eighteen of the cases were so shortly reported as to be of no great value in a review. The remaining forty cases are set out as reported by their authors. Millbourn's first case appears among the 18 cases of "*vesica duplex*" discovered at operation, and is interesting in that the first gall-bladder was removed in 1931, both it and the cystic duct being packed with stones; while the second one, which was reported as small and normal at that time, was removed seven years later, in 1938, after a period of symptoms dating from six months subsequent to the first operation. This was a true case of double gall-bladder with separate cystic ducts opening separately into the common duct.

Millbourn's second case comes in the group of "*vesica divisa*" demonstrated by operation, the double gall-bladder being discovered during an operation on a dermoid cyst arising in close association with the second part of the duodenum. The two halves were of approximately equal size, stretched together over the cyst and reaching nearly to the liver margin. They were almost completely separated, and were both noticed to fill well, the first mainly at the beginning of the operation, the second towards its close. Each half gave the appearance of a normal but small gall-bladder. Millbourn finds in his review of these cases that in by far the greater number of them the two gall-bladders lie in close contact with one another, and generally in a common peritoneal sheath. In most cases in this series the peritoneal covering was such that it gave no external indication at all of the abnormality beneath it. For the two organs to be widely separated is relatively rare.

In four of the 40 cases other malformations of the patient's body were noted. In one there were three hepatic ducts; in another polydactyly in both hands and feet was present; in a third case congenital cardiac deformity was discovered; while in Millbourn's second case there was the teratomatous cyst.

It is not clear that a double gall-bladder is in itself likely to cause any symptoms. In 12 cases out of these 40 there were no symptoms referable to the bile tracts. In 22 of them the abnormality was discovered during operation for symptoms of cholelithiasis or cholecystitis; but there is no case in which the abnormality itself as such could be blamed for the symptoms. It may be concluded that the presence of this abnormality should predispose to the usual pathological conditions common to the bile tracts, namely, inflammation and stone formation; but it is difficult to find evidence on which to fasten any such relation.

ARTHUR E. BROWN.

Reviews.

Illustrations of Regional Anatomy. By E. B. JAMIESON, M.D.; Sections 1 to 5; Third Edition; 1941. Edinburgh: E. and S. Livingstone. Foolscap 4to. Price: 36s. 6d. net.

JAMIESON'S "Illustrations of Regional Anatomy" is so well known that it needs no introduction, and the production of the third edition, which consists of sections 1 to 5, is noted with pleasure.

The chief feature of the new edition is the addition of more colours to the illustrations, some plates containing seven different shades. The alterations are well worth while as they emphasize the different structures depicted.

There have been some minor alterations and new inclusions, making the total number of plates in the five volumes 218. Although diagrammatic, the illustrations are extremely useful for quick revision before examinations or to refresh one's memory before embarking on an operation in one of the less frequented regions.